EMPIRICAL ANALYSES OF THE TERM STRUCTURE OF INTEREST RATES

BY

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EMPIRICAL ANALYSES OF THE TERM STRUCTURE OF INTEREST RATES

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The purpose of this study is to enhance the current understanding of the term structure of interest rates. The term structure of interest rates is defined as the relationship between various bond yields that differ only by maturity.

Five issues are analyzed in this study. The first two problems concern term premiums. The latter three problems examine bid-asked spreads.

The first problem is to examine term premiums in Treasury bill holding period returns. For most periods examined no second order stochastic dominance is found between monthly returns for the first five month maturities. When a riskless asset is assumed, however, the first two maturities are dominated. Therefore, term premiums are not economically meaningful if there is no riskless borrowing and lending. The term premiums are economically meaningful when a riskless asset is available.

The second problem is to compare term premiums in the Treasury bill holding period returns to term premiums in Treasury note holding period returns. Stochastic dominance is employed to evaluate whether the difference in returns of these two securities is economically meaningful. Because bills tend to dominate notes, it is concluded that the impact of coupon payments gives bills an economically meaningful increase in before tax returns.

The third problem is to examine reported bid-asked spreads in the Treasury bill market. For most periods examined, maturity had significant explanatory power in accounting for the variation in the bid-asked spread at a point in time.

The fourth problem is to examine the impact of bid-asked spreads in Treasury bills on assessments of future spot interest rates and future term premiums. The intent is to determine whether incorporating transaction costs alters conclusions regarding the information in forward interest rates about future spot interest rates and time varying premiums. Because no significant change was found by incorporating the bid-asked spread, it was concluded that incorporating transaction costs does not alter the results.

An analysis of the final problem showed that term premiums are reduced dramatically by incorporating transaction costs.

CHAPTER I
INTRODUCTION TO THE STUDY

The term structure of interest rates is the relationship between various bond yields that differ only by maturity. Major term structure theories can be categorized as either an expectations hypothesis or a preferred habitat hypothesis. Expectation hypotheses are based on either the notion that anticipations of future interest rates influence the term structure or that a bond's holding period returns are the same. Preferred habitat hypotheses are based on maturity preferences; that is, market participants require a premium to be "lured" from a specific maturity bond into a different maturity bond.

In empirical research on term structure behavior, attempts have been made to establish whether forward rates are unbiased estimates of expected spot rates in the future. (See, for example, Fama (1976a) and Malkiel (1966).) In other related research attempts have been made to determine whether expected holding period returns for various maturity bonds are the same. (See, for example, Fama (1984b), McCallum (1975), and Roll (1970, 1971).) While much of this research has been useful, our understanding of term structure behavior continues to be somewhat nebulous.

Through the research reported in the present study, it is hoped that the term structure's behavior will be better understood.

The beneficiaries of a better understanding of term structure behavior would include monetary policy makers in their attempts to influence interest rates, financial planners in their need to forecast future interest rates, and macroeconomists in the study of multiperiod consumption-investment decision making. Also those concerned with the term structure as used in bond pricing and the pricing of most other financial claims would be helped.

Problems Addressed

While perusing the empirical literature related to the term structure, five problems for further examination were identified. The first two problems focus on term premiums; the latter three deal with transaction costs. First, several techniques are applied to determine whether term premiums, which are the differences between long-term bills holding period return and the current spot rate, are ecomonically meaningful. Secondly, stochastic dominance is used to assess the differences in historical returns of U.S. Treasury bills and U.S. Treasury notes. Thirdly, an examination is made of factors influencing transaction costs as measured by the reported bid-asked spreads. Fourthly, an analysis is performed of whether there is useful information in bid-asked spreads for forecasting future term premiums and future spot rates. Finally, term premiums are re-examined in light of transaction costs.

The first problem focuses on research methodology. In tests of the local expectations hypothesis, which states that holding period returns should equal the current spot rate, inference is usually based solely on comparison of means. For example, Fama (1984b) found that the average term premiums (holding period returns less the spot rate) are significantly positive using Hotelling's T square test and using Bonferroni multiple comparison test. Fama (1984b, p. 539), however, reports monotonically increasing standard deviations with respect to maturity; that is, accompanying the higher premiums is higher variation. A more convincing test of this hypothesis would be to determine if investor preferences can be established between return distributions. Specifically, if the local expectations hypothesis is true, then stochastic dominance between return distributions should not be observed unless the investor class is not misspecified. (The first derivative of utility is positive, the second derivative is negative, and so forth.)

The second problem emphasizes security characteristics. Applying stochastic dominance to return distributions of U.S. Treasury bills and U.S. Treasury notes, an effort is made to determine whether the ex-post holding period return distributions are distinguishable for these two securities when they have the same maturity. This analysis seeks to establish whether these two securities are pure substitutes despite the notes being coupon-bearing.

The third problem is to analyze market frictions. Market frictions are impediments in the markets which hinder the efficient trading of securities, impediments would include transaction costs, as well as taxes and institutional restrictions. Theoretical models of the term structure tend to ignore market frictions; nonetheless, market frictions have been identified as influencing the term structure. Malkiel identifies transaction costs as his first amendment to his "perfect certainty analysis" of the term structure (1966, p. 103). Malkiel asserts that the only transaction costs paid by major investors in default-free bonds is the dealer bid-asked spread (1966, p. 105). To determine what factors influence the magnitude of the bid-asked spread is the problem addressed in this study.

The fourth problem focuses on the ability to predict using reported data about the term structure. Specifically, the bid-asked spread is incorporated into forecasts of future term premiums and future spot interest rates in an effort to provide better predicting power. It is hoped that by incorporating bid-asked spreads that a more refined estimate will be used reducing measurment error. Fama's (1984a) regression approach is used.

The final problem is to consider the impact of transaction costs on term premiums. The techniques to be employed in the resolution of the first problem are applied here.

Previous Research

The analysis of whether term premiums are economically meaningful is derived from one version of the expectations hypothesis; namely, the assertion that the return over the next holding period is the same for all maturities. Culbertson (1957) was the first to examine whether holding period returns were the same for different maturities. He compared Treasury bills with long-term Treasury bonds for one week and three month holding periods. He concluded that the expectations hypothesis was not an adequate explanation of the term structure of interest rates.

Michaelsen (1965) demonstrated theoretically that, if you assume risk aversion, then the anticipated holding period returns for longer maturities should be higher. However, he remained inconclusive as to the empirical evidence. Roll (1970, 1971) presented a portfolio approach to explaining the term structure using the Capital Asset Pricing Model. He found some evidence of a risk premium in returns, implying an upward-sloping term structure on average. McCallum (1975) extended this work using Canadian bonds. McCallum found that both the standard deviation and beta increase with maturity but the expected return only increased up to three years and leveled off.

Cox, Ingersoll, and Ross (1981) provided rigorous theoretical support for the version of the expectations hypothesis asserting that expected holding period returns for all maturities are equal. These results, however, hinge on the ability to form a riskless portfolio similar to that of the Arbitrage Pricing Model.

The work presented here builds on and extends the work of Fama (1976a, 1984b). Fama used statistical techniques in an effort to determine the significance of the excess of longer-term bonds holding period returns over the present spot rate or the term premium. He finds statistically significant term premiums.

The effort to determine whether the return distributions of notes and bills are similar stems from the need to assess the effect of coupon payments on holding period returns. In 1969, Pye examined the effect of tax-exempt coupons and capital gains on bond yields and brought up several issues related to this present study. It is well known that part of the return on bonds selling below par is capital gain which is taxable at a lower rate. Pye noted a difference in yields between high and low coupon issues where low coupon bonds had lower yields than high coupon bonds. He attributed this to the advantage of capital gains of low-coupon bonds.

McCulloch (1975a,b), Robichek and Niebuhr (1970), Livingston (1979a,b) as well as others have demonstrated that taxes impact yield to maturity which in turn influences holding period returns. Livingston demonstrates when before-tax zero coupon rates are the same for all maturities the yield curve for coupon-bearing bonds will rise with maturity. However, if the after-tax zero coupon rates are constant, then the coupon-bearing yield curve for non-par bonds will take a wide variety of shapes. Based on this theoretical work, there exists no a priori reason to expect before-tax zero coupon Treasury bill returns to be higher or lower than Treasury note returns.

Recently, Fama (1984b) examined returns on U.S. Treasury bills and on U.S. Government bond portfolios. He concludes that reliable inferences are limited to maturities up to one year (bills) because of the high variability of longer-term bond portfolio returns. Fama found that the highest average return for bonds was always less than four years. Also the highest average return on a bond portfolio never exceeded the highest average return on bills. Once again, the research herein presented builds on and extends the work of Fama (1976a, 1984b).

The analysis of market frictions in an effort to determine what factors influence the size of the bid-asked spread is not new. Demsetz (1968) identified the bid-asked spread for stocks to be the cost to investors for immediacy.

That is, investors would be willing to pay a dealer in order to transact immediately rather than to bear the risk of a price change by waiting for a seller or buyer to arrive.

In 1985, Stoll performed an economic analysis of the stock exchange specialist system. He identified three major cost categories, order processing costs, inventory holding costs, and adverse information costs. Inventory holding costs refer to the cost associated with a dealer unbalancing his own portfolio thus giving him additional risk. Adverse information costs refer to the losses to the specialist from trading with people with superior information. Traders with superior information that justifies a different price than the quoted bid-asked price can expect to make profits at the specialist expense, implying larger bid-asked spreads.

Grant and Whaley (1978) showed that a bond's risk, as measured by its duration, is an important determinant of the bid-asked spread. Using the par value of bonds outstanding as a proxy for transaction volume, they found a significant relationship between volume and the bid-asked spread.

The previous research on prediction capabilities of the term structure of interest rate is somewhat mixed. According to the unbiased expectations hypothesis, the implied forward interest rate should be an unbiased predictor of the subsequently observed spot interest rate. Several papers have tested this hypothesis by examining the difference between the implied forward rate today and the future observed spot rate. These prediction errors have been found to be positive on average and increasing with maturity, leading investigators to the rejection of the unbiased expectations hypothesis.

Another way of testing the unbiased expectations hypothesis, referred to as error-learning, has been presented by Meiselman (1962). The Meiselman approach correlates prediction errors between the nearest forward rate and the subsequently observed spot rate with revisions in distant forward rates. The prediction errors have been found to be highly correlated with revisions of distant forward rates, with these correlations decreasing as distance into the future increases. The Meiselman results have been regarded as strong support for the unbiased expectations hypothesis. Thus, there have been several tests of the unbiased expectations hypothesis, with opposing conclusions. Fama (1984a) uses the regression technique to make assessments about the information contained in the term structure. Specifically, he assesses the ability of the difference between the forward rate and the current spot rate to predict time varying term premiums and changes in the spot rates. He found predictive power for the short-term (two to three months) but not for the longer term.

In a study examining Treasury bill futures contracts ability to guage interest rate expectations, Poole (1978) notes that " . . . the relationship of transaction costs to term premiums has never been carefully investigated. (p. 9)" He provides some preliminary evidence that the shape of the term structure may be due in part to transaction costs.

CHAPTER II
AN EMPIRICAL ANALYSIS OF TERM PREMIUMS

The purpose of this chapter is to examine term premiums in U.S. Treasury bill holding period returns. Several techniques are employed to determine whether the observed term premiums are economically meaningful. For most periods examined no second order stochastic dominance was found between monthly returns for the first five month maturities. When a riskless asset is assumed, however, the first two maturities were dominated. Therefore, though there are statistically significant term premiums they are not economically meaningful if there is no riskless borrowing and lending. The term premiums are economically meaningful, however, in the sense that the longer maturities dominate the shorter maturities when a riskless asset is available. The results are similar for longer holding periods.

Term premiums not only exist but are statistically significant at least for short term Treasury bills; this fact has been well documented. (See, for example, Roll (1970, 1971), Fama (1976a, b, 1984a, b) and Startz (1982).) More recently, Fama reported statistically significant term premiums as measured by the excess of the holding period return on a multi-month bill over the current spot rate (the yield to maturity on bonds with one month to maturity). (See Fama (1984b), p. 535, especially Table 2.) Accompanying these positive though non-monotonically increasing premiums, however, are monotonically increasing standard deviations, where monotonic is with respect to maturity. (See Fama (1984b), Table 4, p. 539.) Thus, even if term premiums exist, there economic meaning is questionable.

In this chapter, the problem is to determine whether these statistically significant average term premiums are economically meaningful. Unlike Choi (1985) who sought to explain the term premium using the Arbitrage Pricing Theory, this chapter is to determine whether the term premium is sufficient to conclude that a certain class of investors (for example, all risk averters) will prefer one maturity over another one. Stochastic dominance as well as other criteria are used to make these economic inferences.

To illustrate the issue, suppose that the investor's holding period is one month. Since the investor can buy a bond which matures in one month, the return is given by the one-month spot rate. However, the investor can buy a bond with n months left to maturity where n = 2, 3, . . . , 12 and sell it after one month when n-1 months to maturity are left (only bonds with maturities up to 12 months are considered). In this case the investor's return is a random variable since the yield curve may shift from one period to another. The investor, therefore, faces the random variable $R(1,n)$ where the one indicates that the holding period is one month and n denotes the maturity of the bond purchased. The ex-post distribution of the returns $R(1,n)$ can be measured by observing the returns $R(1,n)$ for each month during the period under consideration. $F(1,n)$ denotes the distribution of $R(1,n)$. There are 12 distributions to compare and to chose from, where the number of observations for each distribution, in principle, is equal to the number of months covered in the study.

Previous empirical studies have tested mainly whether the means of $F(1,n)$ are statistically different from each other. (See, for example, Fama (1984b).) If $E(R(1,n)) > E(R(1,n-t))$ $(0 < t < 12)$ for all $n > 1$ and for all relevant t, and if this difference is statistically significant one can conclude that significant liquidity premiums exist in the bond market. Fama (1984b) found that the difference $E(R(1,n) - R(1))$, $(n = 2, 3, \ldots, 12)$ is positive and significantly different from zero. There is a term premium, therefore, in comparison to the one month spot rate.

In this chapter, whether there is an economic difference between the 12 distributions $F(1,n)$ $(n = 1, 2, \ldots, 12)$ is tested rather than testing for statistical difference of the means of the distributions. An economic difference is said to exist if investors are better off by choosing one investment strategy over the other. For example, if one finds that for maturity n = 4, distribution F(1,4) dominates (by a certain decision rule) all other investment strategies, one may conclude that irrespective of the means of these distributions, this distribution is the most desirable since it maximizes the investor's expected utility. Efficient investment strategies are sought, that is, to recommend which maturities of bonds constitute the efficient set of investment strategies.

Obviously, the content of the efficient set (or the optimal choice) is a function of the assumptions one is willing to make. The following alternative sets of assumptions are made.

1. Returns are normally distributed, and investors hold only a portfolio of bonds with a maturity of n months (n = 1, 2, . . . , 12).

2. Returns are normally distributed and the Capital Asset Pricing Model (CAPM) holds; namely, a large portfolio of risky assets is held with the specific bonds under consideration.

3. Returns are not normal and investors consider mean, variance and skewness in their decision making process.

4. No assumption is made regarding the return distribution. In this case first, second, and third degree stochastic dominance rules (FSD, SSD, and TSD) are applied where $u'>0$, $u'>0$ and $u''<0$, and $u'>0$, $u''<0$ and $u'''>0$, respectively, are assumed.

5. In addition to 4. as stated above, investors are allowed to borrow and lend at the one-month spot rate ignoring transaction costs. In this case stochastic dominance rules with a riskless asset are applied which are known in the literature as FSDR, SSDR, and TSDR, where R stands for the existence of the riskless asset.

While there is no one framework which is the "true framework," and each one has its pros and cons, in general, the more assumptions that are made, the smaller is the number of investments included in the efficient set. Rather than arguing which framework is superior to the other, the efficient sets derived under alternate models are investigated.

The format of this chapter is as follows. A brief review of the literature is given in the next section. Then monthly holding period returns are examined by using performance measures and decision criteria which are based on the mean-variance or the mean-variance-skewness approach. Next these returns are examined using stochastic dominance and finally stochastic dominance is used assuming a riskless asset exists. The analysis is then extended to the multiperiod case.

Previous Research

The analysis of the economic meaning of term premiums is derived from one version of the expectations hypothesis. The two major emphases of this hypothesis are 1) the return over the next holding period is the same of all maturities and 2) the return from holding a long-term bond is equal to the return on a series of investments in short-term bonds. The primary focus here is on 1).

Culbertson (1957) was the first to examine whether holding period returns were the same for different maturities. He compared Treasury bills with long-term Treasury bonds for one week and three month holding periods. He concluded that the expectations hypothesis was not an adequate explanation of the term structure of interest rates. Culbertson put forth what is now known as the market segmentation hypothesis which asserts that investors have strong maturity preferences and so bonds of varying maturities are not substitutable. A more refined version of this was put forth by Modigliani and Sutch (1966) which is called the preferred habitat hypothesis. In this version monotonically increasing premiums are not necessary.

Hicks (1946), based on the notion of risk preferences of investors, presented the "liquidity preference hypothesis." This hypothesis asserts that forward rates are systematically higher than the expected spot rates and increasing in magnitude as the time to maturity is larger.

Michaelsen (1965) demonstrated theoretically that, if you assume risk aversion, then the anticipated holding period returns for longer maturities should be higher. However, he remained inconclusive as to the empirical evidence.

Roll (1970, 1971) presented a portfolio approach to explaining the term structure using the Capital Asset Pricing Model. Roll concludes, "the data did indicate that portfolio risk components of Treasury bills, as measured by . . . (beta), increased with term-to-maturity. This implies an upward-sloping term structure on average" (1971, p. 65). McCallum (1975) extended this work using Canadian bonds. He considered a three month holding period and looked at bonds with maturities from three months to 240 months. He calculated both the standard deviation and beta which both rely on the normality assumption to be a valid risk measure. It will be shown later that bond holding period returns are positively skewed which violates the normality assumption. McCallum found that both risk measures increase with maturity but the expected return only increased up to three years and leveled off.

Cox, Ingersoll, and Ross (1981) provided rigorous theoretical support for the version of the expectations hypothesis asserting that expected holding period returns for all maturities are equal. These results, however, hinge on the ability to form a riskless portfolio similar to that of the Arbitrage Pricing Model.

This present chapter builds upon and extends the work of Fama (1976a, 1984b). Fama used statistical techniques in an effort to determine the significance of the excess of longer-term bonds holding period returns over the present spot rate or the term premium. He finds statistically significant term premiums.

Mean-Variance and Mean-Variance-Skewness

Data

The data are taken from the 1985 CRSP Government Bond Tape, specifically the FAMAFILE which contains Treasury bill monthly holding period returns from September 1964 through May 1985. Periods in which there is missing data are deleted entirely. Included in the sample are 239 observation periods with each period including monthly holding period returns for the first 12 months on the term structure.

Risk Measures

Fama (1984b) presented evidence that both the mean and the standard deviation of holding period returns increase with maturity. This seems reasonable since risk and return go up simultaneously. The real question in testing if the term premium is economically meaningful is how to adjust for risk; that is, what is the relevant risk index. There are a few alternatives each of which has different underlying assumptions:

a) Treynor's (1965) performance index

$$I(T) = (E(R(n)) - r) / B(n)$$

where r is the risk-free rate and B(n) is the beta from the Capital Asset Pricing Model (CAPM). This performance measure assumes risk aversion and the other assumptions of the CAPM; particularly, riskless borrowing and lending and normal distributions.

b) Jensen's (1968) excess return index a(n), derived from the regression

$$(R(n,t) - r(t)) = a(n) + B(n)(R(m,t)-r(t)) + e(n,t)$$

where R(m,t) is the "market" portfolio holding period return observable at t and e(n,t) is the residual error. This performance index makes the same assumptions of a) above, however, it does not yield necessarily the same ranking.

c) Sharpe's (1966) index

$$I(S) = (E(R(n)) - r) / s(n)$$

assumes normality of returns and that the risk index is s(n), the standard deviation of the return on R(n), rather than B(n); that is, the investor holds only one risky asset in his portfolio (can be a portfolio of bonds with n months to maturity). See Levy and Sarnat (1984) for details.

d) Arditti's (1971) index is similar to Sharpe's index, but in order to have dominance Arditti requires also that the skewness of the superior investment will be larger (by Sharpe's index) than the inferior one. Obviously, Arditti implicitly assumes non-normal distributions since he considers skewness and not only the mean and variance.

These four performance frameworks share one commonality: they allow borrowing and lending at a risk-free interest rate.

Table 2.1 presents the mean, standard deviation and skewness for each of the 12 investment strategies. Note that indeed a term premium exists so the mean return tends to increase with maturity, though this increase is not monotonic, reaching its peak at n=9. A liquidity premium is observed in comparison to one-month bonds since E(R(n)) > E(R(1)) for n = 2, 3, . . . , 12.

TABLE 2.1

Univariate Statistics

Monthly Returns 9-64 through 5-85

Months to Maturity (when purchased)	Mean	Standard Deviation	Skewness
1	.00559	.0024	1.155
2	.00590	.0026	1.351
3	.00617	.0030	1.546
4	.00622	.0033	1.944
5	.00638	.0037	2.125
6	.00637	.0041	2.203*
7	.00633	.0044	1.923
8	.00652	.0049	1.862
9	.00657*	.0056	2.026
10	.00628	.0062	1.872
11	.00636	.0065	1.855
12	.00648	.0070*	1.796

*Peak

The standard deviation, unlike the mean, increases monotonically with maturity, reaching its peak at n = 12, where s = .0070. The third column of Table 2.1 reveals that the skewness is always positive. While it also has a tendence to increase with maturity, it fluctuates, reaching its peak at n = 6. When using the M-V rules or the CAPM normal distributions of returns are assumed. The positive skewness appearing in Table 2.1 indicates that some other rules which do not rely on the normality assumption are required. If the investment is normal and the positive skewness is due to sampling error, some positive skewness and some negative skewness would be expected[1] (six positive and six negative). Nonetheless, before turning to the distribution-free decision rules, M-V decision rules and conventional performance indices which do rely on the normality assumption are presented.

M-V Decision Rules

Assuming no riskless asset one can apply the well-known M-V rules to the figures of Table 2.1 to establish the efficient and the inefficient sets. The M-V rule in this context is as follows: A return distribution F(n) dominates or is preferred to another return distribution F(m), where n is not equal to m (n = 1, 2, . . . , 12 and

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[1] Under the normality assumption, the probability to obtain 12 positive skewness is extremely low (0.000244, one half raised to the twelveth power).

$m = 1, 2, \ldots, 12$), by the M-V rule if and only if the expected return of F(n) is greater than or equal to the expected return of F(m) and the variance of F(n) is less than or equal to the variance of F(m) with at least one strong inequality.

Based on this criteria, months 1 - 5, 8, and 9 are in the efficient set (undominated). Months 6, 7, 10, 11, and 12 are in the inefficient set (dominated). Hence, if investors are risk averse and returns are assumed normal, all investors will prefer to invest in one of the portfolios in the efficient set (1 - 5, 8, 9) rather than one in the inefficient set (6, 7, 10, 11, 12). Notice that the dominated securities (month 6 for example) are dominated by shorter maturity securities. Of particular interest is the large positive skewness exhibited in Table 2.1.

Arditti (1971) suggested considering both Sharpe's index and skewness simultaneously when comparing securities (see Table 2.2 for Sharpe's index). His rule is that one return dominates another if it has both a higher Sharpe's index and higher skewness. Based on this criterion and looking at Tables 2.1 and 2.2, it is found that months 5 and 6 comprise the efficient set.

Conventional Performance Indices

In Table 2.2 the values for the three performance indices are presented. The proxy for the market portfolio employed in calculating B (beta) is the value-weighted market portfolio, including dividend, which consisted of all NYSE and AMEX stocks. This index is taken from the 1985 CRSP Stock Tape. (The equally weighted index yields similar results.) A stock-bond index was not used because of the difficulty in justifying whatever index chosen. Thus for the purposes here the value weighted index is sufficient.

TABLE 2.2

Performance Measures

Monthly Returns 9-64 through 12-84

Months to Maturity (when purchased)		Indices	
	Jensen*	Treynor	Sharpe
1	.0	.0	.0
2	.297	-.198	.115
3	.556	1.234**	.192
4	.594	.269	.186
5	.720	.099	.202**
6	.705	.068	.181
7	.643	.047	.157
8	.830	.048	.179
9	.857**	.039	.165
10	.559	.021	.102
11	.618	.021	.105
12	.822	.023	.119

*Jensen's indices are multiplied by 1000
**Peak

From Table 2.2 it is concluded that the preferred maturity depends on the index selected (or the assumptions one is willing to make). Using Sharpe's index investing in a five month Treasury bill is the preferred investment. Using Treynor's index investing in a three month bill is preferred and using Jensen's index the nine month bill is preferred.

Efficient Frontiers

Another method to evaluate the quality of various return distributions would be to calculate efficient frontiers and examine which securities are contained in the portfolio at various points on the frontier. If all twelve securities are included in the portfolio then although some are dominated by M-V they are useful in the portfolio context. This approach assumes that investors consider both expected return and variance in investment decision making and usually results in investing in several securities. Returns are assumed to be normal and also all the other assumptions of the CAPM. A numerical method known as quadratic programming is used which attempts to minimize the portfolio risk (as measured by variance or standard deviation) at each given return level, but additional nonnegativity constraints are imposed which require that no maturity can be held in negative proportions. The procedure can be expressed as follows: Minimize portfolio variance subject to a given portfolio's mean, all proportions must add to one, and all proportions must be greater than or equal to zero. See Levy and Sarnat (1984), chapter nine for more details.

Table 2.3 shows these frontiers with and without the stock index. Under these assumptions the efficient sets contain 1, 3, 12, and the index and 1, 5, and 12 without the index. The efficient frontier is not much improved over individual investments because of the extreme positive correlation between these returns. The inclusion of maturity 12 is unique to this approach. Maturity 12, therefore, may be valuable in a portfolio context.

TABLE 2.3

Efficient Frontiers

A. With Index

		Percent Invested			
	Standard		Securities		
Mean	Deviation	Index	1	3	12
0.0075	.0349	93.1			6.9
0.0070	.0134	36.5			63.5
0.0067	.0062	10.1		14.7	75.1
0.0065	.0045	6.8		52.5	40.7
0.0063	.0036	3.2		89.6	7.3
0.0062	.0032	2.5	8.8	88.7	2.5
0.0061	.0030	2.3	23.5	74.2	
0.0056	.0022	1.8	98.2		

B. Without Index

		Percent Invested		
	Standard		Securities	
Mean	Deviation	1	5	12
0.0066	.0062		30.6	69.4
0.0065	.0051		70.2	29.8
0.0063	.0035	14.5	85.5	
0.0061	.0035	37.7	62.3	
0.0059	.0028	61.0	39.0	
0.0057	.0026	87.8		12.2

Table 2.4 summarizes the results obtained thus far. Out of the 12 investment strategies (the feasible set), the M-V

efficient set includes portfolios 1 - 5, 8, and 9. Sharpe, Jensen and Treynor selections are taken from the M-V efficient set while Arditti's efficient set consists of one investment taken from the M-V efficient set and one taken from the inefficient set. This is not surprising since Arditti considers skewness as well as variance. Also the efficient frontier uses only securities 1, 3, and 12 when a market index is assumed and securities 1, 5, and 12 when a market index is not assumed.

TABLE 2.4

The Investment Selection by Various Rules

	Months to Maturity											
Feasible Set	1	2	3	4	5	6	7	8	9	10	11	12
M-V Efficient Set	*	*	*	*	*			*	*			
Jensen's Index									*			
Treynor's Index			*									
Sharpe's Index					*							
Arditti's Index					*	*						
Efficient Frontiers												
With Index	*		*									*
Without Index	*				*							*

Therefore, up to this point, it is clear that the conclusions drawn about the economic value of term premiums depend heavily on the equilibrium model assumed or the decision criteria employed. For this reason, the stochastic dominance technique is advocated because it requires minimal assumptions and is flexible enough to be able to add assumptions to strengthen the test.

Applying Stochastic Dominance

Stochastic Dominance Rules

Stochastic dominance criteria were developed in 1969-70 when four papers were published by Hadar and Russell (1969), Hanoch and Levy (1969), Rothschild and Stiglitz (1970) and Whitmore (1970). The benefits of stochastic dominance (SD) rules are that they allow inferences to be made with only partial information about investor preferences and no assumptions regarding the nature of the distribution. SD rules are based on three classes of utility functions $U(i)$, where $i = 1, 2, 3$, where u belongs to $U(1)$ if $u' > 0$; u belongs to $U(2)$ if $u' > 0$ and $u'' < 0$; and u belongs to $U(3)$ if $u' > 0$, $u'' < 0$ and $u''' > 0$. The decision rules are called first, second and third degree stochastic dominance (FSD, SSD, and TSD, respectively) based on the utility class $U(i)$, $i = 1, 2, 3$, respectively. The decision rules are as follows: Let F and G be the cumulative distribution of two distinct options (say $F(n)$ and $F(1)$, where $F(n)$ is the holding period return distribution generated by purchasing an n maturity bill ($n = 2, 3, . . . , 12$) and selling it one month later and $F(1)$ is the distribution of one month returns). Then F dominates G (FDG) by FSD, SSD, and TSD, if and only if

FSD: $F(x) < G(x)$ for all x (2.1)

SSD: $S(G(t) - F(t))dt > 0$ for all x (2.2)

TSD: $SS(G(t) - F(t))dtdv > 0$ for all x (2.3) where S represents the integral from minus infinity to x (a dummy argument). The inside integral of TSD runs from minus infinity to v (another dummy argument). (Also, in all rules there is a strict inequality for at least one value x.)

If investors in these securities invest in only one maturity and belong to U(i), i = 1, 2, or 3 and term premiums are not economically meaningful, then no FSD (for i = 1), SSD (for i = 2) or TSD (for i = 3) is anticipated. If economically meaningful (under the above conditions) term premiums exist, then dominance is anticipated. Namely, if dominance exists, not only the mean increases with maturity, but also the whole distribution changes such that the investor's expected utility increases. If monotonically increasing term premiums are expected (based on the liquidity preference hypothesis), and they are economically meaningful, then longer maturity bills will dominate the shorter maturity bills, and in particular the spot rate as has been found by Fama (1984b).

Empirical Results

Results are presented in Table 2.5 along with the results for selected subperiods. Subperiods are selected so that comparison can be made with Fama's (1984b) Table 2 analyzing the statistical significance of term premiums. Table 2.5 presents the efficient sets under the three various assumptions about utility U(i), i = 1, 2, 3. The numbers which appear in the table are the maturities which are undominated. For example, for the overall time period (8/64 - 5/85) and for i = 2 (SSD), the efficient set contains maturities 1 - 5, 8, and 9. This indicates that these return distributions are not dominated. Therefore, maturities 6, 7, and 10 - 12 are dominated by at least one maturity taken from the efficient set.

TABLE 2.5

Efficient Sets for Treasury Bill Returns

Time Period	Number of Observations	U(i), (i = 1, 2, 3) 1 FSD	2 SSD	3 TSD
8/64-5/85	239	1-12	1-5,8,9	1-5,8,9
8/64-12/82	210	1-12	1-5,8,9	1-5,8,9
8/64-12/72	101	1-12	1-3,5-9,12	1-3,5-9,12
1/73-12/82	109	1-12	1-5,8,9	1-5,8,9
1/78-12/82	54	1-12	1-5	1-5
6/80-5/85	58	2-12	2-5,8,9	2-5,8,9

In all cases (except maturity one for subperiod 6/80 - 5/85), maturities are dominated by a shorter maturity. This is exactly the opposite result expected if the liquidity preference hypothesis were true and the premiums were economically meaningful. The significant lower return of distribution F(1) found by Fama (1984b) is not economically meaningful since longer maturity distributions have other desired properties; hence it is not relegated to the inefficient set.

Notice that the efficient set of SSD for the whole period is identical to the mean-variance efficient set presented above. This result is startling in light of the fact that the distributions are positively skewed. This is also true for each subperiod. These results are derived without making the invalid assumption of normality. Finally, the assumption that u'" > 0 (U(3)) is not binding for these periods.

Kroll and Levy (1980) evaluated the possible effects of sampling errors on SD and MV rules. They used simulation and covered a wide range of correlations and return distributions (normal, lognormal, and uniform). Their main result was that FSD is highly effected by sampling error and not SSD, TSD, and MV. In many cases they found that sampling error probabilities actually increased with an increase in the sample size for FSD. The sampling error probabilities decreased rapidly, however, for an increase in sample size for SSD, TSD, and MV. The last two time periods have higher probabilities of sampling error than the others for SSD, TSD, and MV. The consistency of these results across time periods indicates that sampling error is not a problem.

Bawa (1980) examined the theoretical impact of sampling error using a Bayesian framework. He " . . . show(s) that in a non-parametric context with sample data being the only information available, empirical distribution functions are the appropriate distribution functions to be used in making optimal choice among unknown distributions. (p. 57)"

These findings indicate that, based on the assumptions that investors are risk averse and select bonds based on their historical distributions, economically meaningful term premiums do not appear to exist. In the next section, it is assumed that investors are allowed to mix the risky bonds with the riskless asset.

Stochastic Dominance with a Riskless Asset

Levy and Kroll (1976) applied the quantile approach to develop stochastic dominance criteria with a riskless asset (SDR). With the additional assumption that investors can borrow and lend at a risk free interest rate, these criteria (SDR) afford dominance in distributions that would not be established by the SD criteria.

An Illustration

It is possible, therefore, that distribution F does not dominate distribution G by FSD but that such a dominance does exist by FSDR. With a riskless asset, a smaller efficient set may be obtained. To illustrate this point suppose that one faces two distributions F and G given as follows:

F		G	
Return	Probability	Return	Probability
1.5	1/4	0	1/2
2.5	3/4	3	1/2

The return on the risk free asset is assumed to be 1.5. Obviously, by FSD neither F nor G dominates the other since the two distributions cross (see Figure 2.1). However, adding the possibility to borrow or lend money reveals that dominance prevails. With this set of parameters, F clearly dominates G by FSDR (first degree stochastic dominance with a riskless asset).

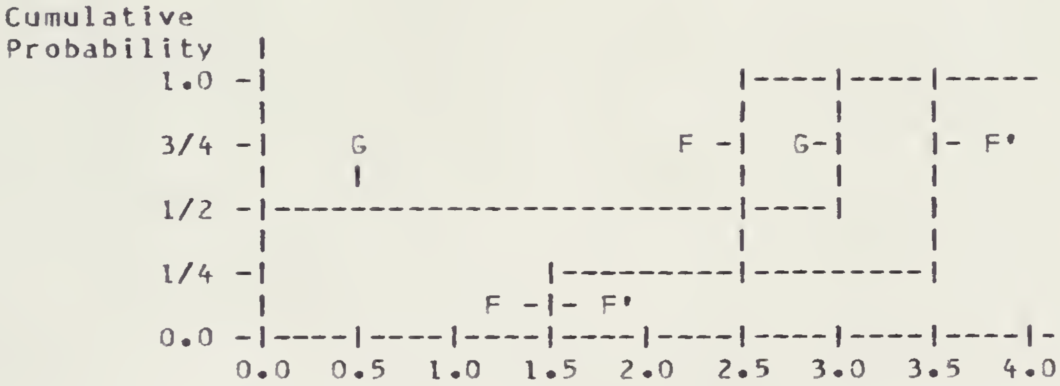

Figure 2.1: Illustration of FSDR without FSD

To see this, create a new distribution F' where under this strategy \$1.00 is borrowed and \$2.00 (the borrowed money plus the initial wealth) is invested in F. The return on F' is

F'

Return	Probability
2 x 1.5 - 1.5 = 1.5	1/4
2 x 2.5 - 1.5 = 3.5	3/4

note that F' dominates G by FSDR (see Figure 2.1). The claim, that this is an unfair comparison since F is mixed with the riskless asset and G is not, is not true since for any arbitrary mix of G with the riskless asset, one can find another mix of F with the riskless asset which dominates it. For example, suppose that $1.00 is borrowed and a new distribution G' is created:

G'

Return	Probability
2 x 0 - 1.5 = -1.5	1/2
3 x 2 - 1.5 = 4.5	1/2

Clearly F' does not dominate G' by FSD since the two distributions cross each other. It is possible to create a new distribution F" which dominates G'. For example, borrow $2.00 and invest in F, resulting in

F"

Return	Probability
3 x 1.5 - 2 x 1.5 = 1.5	1/4
3 x 2.5 - 2 x 1.5 = 4.5	3/4

and hence F" dominates G'. To find one mix of F and the riskless asset which dominates G is to guarantee that any mix of G and the riskless asset will be dominated by some mix of F and the riskless asset. To be more specific, Levy and Kroll (1976) proved specifically that if there is one x such that xF + (1 - x)r dominates G, then for any mix yG + (1 - y)r there is a mix wF + (1 - w)r which dominates it. Having this illustration, it is clear that the SDR efficient sets are subsets of the SD efficient sets (in the weak sense).

Empirical Results

The same set of data and the SDR algorithm developed by Levy and Kroll (1979) are employed. Obviously, in comparison to the last section, the riskless asset is added. It was assumed to be the average spot rate for the period examined. The results are in Table 2.6

TABLE 2.6

Efficient Sets with Riskless Asset

Time Period	N*	Risk-free Rate	U(i), (i=1,2,3)		
			FSDR	SSDR	TSDR
8/64-5/85	239	.0056	1-12	3-5,8,9	3-5,8,9
8/64-12/82	210	.0054	1-12	3-5,8,9	3-5,8,9
8/64-12/72	101	.0039	1-9,11,12	3,5-9,12	3,5-9,12
1/73-12/82	109	.0068	1-12	3-5,8,9	3-5,8,9
1/78-12/82	54	.0088	2-12	3-5	3-5
6/80-5/85	58	.0085	2-12	3-5,8,9	3-5,8,9

*N stands for the number of observations

FSDR rule is very ineffective. For almost all periods studied the efficient set is relatively large, and in three periods out of six it includes all twelve maturities.

A second conclusion which is similar to the previous results is that TSDR yields the same efficient set as the SSDR. There is no need to assume that u'" > 0, since this assumption does not yield any reduction in the efficient set. The main result, however, is that unlike SSD, SSDR reveals that the term premium is economically meaningful. Fama (1984b) showed that a significant term premium exists when one compares E(R(n)) to E(R(1)) (for most values, n = 2, 3, . . . , 12). Using M-V rule or SSD rules (risk aversion) shows that F(1) is included in the efficient set. Though E(R(1)) < E(R(n)), (n = 2, . . . , 12), more information on the distributions under consideration is utilized and M-V and SSD show that the term premium is not economically meaningful. Using SSDR, however, supports the previous temporal conclusion of Fama, namely that the term premium is also economically meaningful since the distributions F(1) and F(2) are not included in the efficient set. (See Table 2.6.) Any investors who are risk averse will be better off selecting investments from the efficient set which does not include F(1) and F(2).

Sensitivity to Risk-Free Rate

One item to consider is the selection of the average spot rate to be the risk-free rate. A rate is needed which would be representative of the market at the time the ex-post data is collected. To assess the problem of possibly selecting an improper risk-free rate an analysis is performed to assess how sensitive the conclusions are to the choice of the risk-free rate. Table 2.7 presents the efficient sets for the entire period under various risk-free rate assumptions. The range of the spot rate for this period was 0.002494 (or 0.2494%) to 0.013593 (or 1.3593%) on a monthly basis. As shown in Table 2.7, however, the results change within these extreme bounds.

TABLE 2.7

Efficient Sets with Different Risk-Free Rates

	Monthly Returns 8-64 through 5-85		
	U(i), (i = 1, 2, 3)		
Risk-Free Rate	1 FSDR	2 SSDR	3 TSDR
0.00225	1-2	1-2	1-2
0.00300	1-6,8,9	2-5,8,9	2-5,8,9
0.00400	1-6,8,9	1-5,8,9	1-5,8,9
0.00420	1-6,8,9,12	1-5,8,9	1-5,8,9
0.00440	1-6,8,9,12	2-5,8,9	2-5,8,9
0.00460	1-6,8,9,12	2-5,8,9	2-5,8,9
0.00480	1-9,12	3-5,8,9	3-5,8,9
0.00500	1-9,11,12	3-5,8,9	3-5,8,9
0.00520	1-12	3-5,8,9	3-5,8,9
0.00540	1-12	3-5,8,9	3-5,8,9
0.00580	1-12	5,8,9	5,8,9
0.00600	1-12	5,8,9	5,8,9
0.00620	1-12	5,8,9	5,8,9
0.00640	2-12	9	9
0.00660	2-12	---	---

From Table 2.7 it is clear that the same general conclusions would be drawn if the risk-free rate was between 0.00440 to 0.00640 (or 5.4% to 8.0% on an annual basis). Thus, the results are fairly insensitive to the choice of the risk-free rate.

Longer Holding Periods

One may argue that investors do not have a holding period of one month. Are the conclusions put forth above the same for longer holding periods? To answer this question the same analysis was performed as the preceeding two sections. However, a refined data set was used due to compounding of measurement error. The data used in the preceeding sections was created by Fama (1984b); he selected a twelve month bill and used the same bill in the calculation of returns in future periods. For example, eight months after the bill was issued it would be used in the calculation of a four month holding period return. Starting on August 28, 1973, however, fifty-two week bills were issued every four weeks, so precise monthly returns are not available after this date. Because bills are issued weekly for a twenty-six week maturity, a bill maturing near month-end is more likely to be available for maturities with less than six months.

From Table 2.8 it is clear that the conclusions remain exactly the same for holding periods of less than nine months. When a riskless asset is not assumed there is no dominance by longer maturity bills. Thus, term premiums do not appear to be economically meaningful. When a riskless asset is assumed, however, there is dominance by longer maturity bills. Thus, term premiums do appear to be economically meaningful.

TABLE 2.8

Efficient Sets for Longer Maturities

Purchase Maturity (Months)	Time Period 8/64 - 5/85						
	N*	FSD	SSD	TSD	FSDR	SSDR	TSDR
2	246	2-11	2-6,8,9	2-6,8,9	2-11	6,8,9	6,8,9
3	244	3-11	3-9	3-9	3-11	7,8,9	7,8,9
4	242	4-11	4-9	4-9	4-11	8,9	8,9
5	240	5-11	5-9	5-9	5-11	9	9
6	238	6-11	6-10	6-10	6-11	9,10	9,10
7	236	7-11	7-11	8-11	7-11	11	11
8	234	8-11	8-11	8-11	8-11	11	11
9	232	9-11	9-11	9-11	9-11	9,11	11
10	230	10,11	10,11	11	10,11	10,11	11

*Number of observations

The market is efficient in the sense that for SSD there exist at least one holding period such that each maturity is in the efficient set. Maturities 1 - 5, 8, and 9 are in the efficient set for monthly returns. Maturities 6 and 7 are in the efficient set for all longer holding periods. For a two month holding period, month 7 is included because maturity 8 is purchased and held for two months. Maturities 10 and 11 are in the efficient set for holding periods of 7 months or longer. The market is inefficient in the sense that for SSDR maturities 1 and 2 are not in the efficient set (except for very long holding periods of 9 and 10 months).

Summary

Comparing the return of long-term Treasury bills to the return of short-term bills, a statistically significant term premium has previously been found. In particular, Fama (1984b) found that a term premium is observed in comparison to the one month return, that is, the spot rate.

In this chapter the question addressed is whether this significant term premium is also economically meaningful or is there a term premium when variance, skewness and other relevant parameters are taken into account. The results indicated that the economic value of observed term premiums in the U.S. Treasury bill monthly holding period returns depends on the set of assumptions one is willing to make.

If one believes that investors make decisions based on the relative characteristics of each maturity bill (that is, the return's distribution) then one would conclude that though the term premiums are statistically significant they are not economically meaningful. On the contrary, there is a tendency for short maturities to dominate long maturities. Thus, from an economic point of view, when the whole distribution is examined and not only the means a negative economic premium prevails.

If one believes that investors make decisions based on the portfolio distribution of each maturity bill and the riskless asset (that is, investors either lever their positions or invest in both the bill and the risk-free asset), then one would conclude that term premiums are both statistically significant and economically meaningful. In this case the premium exists not only with respect to the one month maturity (as Fama documented) but the results are even stronger since the two-month bills are also an inefficient strategy. The results are also the same for longer holding periods.

CHAPTER III

AN EMPIRICAL ANALYSIS OF THE COUPON EFFECT ON TERM PREMIUMS

Whereas the focus of Chapter II was to examine whether the U.S. Treasury bill term premiums are economically meaningful, in Chapter III the focus will be the comparison of term premiums in U.S. Treasury bill holding period returns and term premiums in U.S. Treasury note holding period returns. Stochastic dominance is employed to evaluate whether the difference in returns of these two securities, for similar maturities, is economically meaningful. Bills dominate notes for maturities three, five, six and seven and no dominance is found for other maturities using second order stochastic dominance. When a riskless asset is assumed only maturities one, two and four bills do not dominate notes. Therefore, it is concluded that the impact of coupon payments on notes gives bills an economically meaningful increase in before tax return.

The purpose of this chapter is to determine whether the ex-post return distributions for U.S. Treasury bills and notes differ in an economically meaningful way. That is, by evaluating the difference between return distributions in the bill and note markets for similar maturities, the impact of coupon payments is examined. The intent of this study is to determine whether reliable inferences from the term structure are limited to maturities of one year or less, because bills are not issued for longer maturities.

The null hypothesis is as follows: If bills and notes for the same maturity are pure substitutes, then no economically meaningful difference between bill's and note's returns will be found. If a difference is found between bills and notes then using longer-term securities which are coupon-bearing may produce unreliable inferences. If a difference is not found then the conclusion is less clear. The coupon effect increases in magnitude for longer maturities. The lack of distinction between bills and notes may be due to the short-term maturities used. Bills, however, are only issued for one year maturities or less. Fortunately, a difference is found between bills and notes.

Previous_Research

Theoretical_Research

Although the primary focus of Pye's (1969) study was examining the effect of tax-exempt coupons and capital gains on bond yields, several issues are related to this present study. It is well known that part of the return on bonds selling below par is capital gain which is taxable at a lower rate. Pye observes, "Low-coupon treasuries have recently sold as much as a full percentage point below otherwise comparable issues" (1969, p. 562). Thus, the advantage of capital gains of low-coupon bonds produces lower yields. Pye also points out that "(b)onds selling above par are treated asymmetrically by the tax authorities. On taxables, each year the amortized premium is deducted from taxable income, and also from the cost price (for determining gain or loss). . . . The effect of these provisions . . . is to make bonds selling above par good substitutes for bonds selling at par" (1969, p. 562).

McCulloch (1975a,b), Robichek and Niebuhr (1970), Livingston (1979a,b) as well as others have demonstrated that taxes impact yield to maturity. Thus, this tax effect also influences holding period returns. Livingston examined "(t)he relationship between the yield curves for zero coupon bonds and coupon-bearing bonds . . . " (1979a, p. 189) in a world with differential taxation of coupons and capital gains. Livingston demonstrates when before-tax zero coupon rates are the same for all maturities the yield curve for coupon-bearing bonds will rise with maturity. However, if the after-tax zero coupon rates are constant, then the coupon-bearing yield curve for non-par bonds will take a wide variety of shapes. Livingston also demonstrates that "(i)n the more general case where actual coupons vary with maturity and tax rates differ by maturity, . . . no inferences at all (about the shape of the zero coupon yield curve) should be made" (1979a, p. 189). Thus, based on this research, there exists no a priori reason to expect zero coupon Treasury bill yields to be higher or lower than Treasury note yields. In a related study, Livingston demonstrates that the tax treatment for premium bonds " . . . create(s) the possibility that the 'coupon effect' can have a different sign for discount and premium bonds of the same maturity" (1979b, p. 526). Thus the relationship between yields of notes and bills is further confounded.

Empirical Research

Recently, Fama (1984b) examined returns on U.S. Treasury bills and on U.S. government bond portfolios. He concludes that reliable inferences are limited to maturities up to one year (bills) because of the high variability of longer-term bond portfolio returns.

By aggregating holding period returns for various maturity ranges, Fama found that the highest average return was always a maturity range of less than four years. He also notes the following:

> During periods where the bond file overlaps with the bill file, the highest average return on a bond portfolio never exceeds the highest average return on a bill. We cannot conclude, however, that longer-term bonds have lower expected returns than short-term instruments. Like McCulloch (1975), but with the advantage of an exhaustive data base, we find that the high variability of longer-term bond returns preempts precise conclusions about their expected returns. The bond data are consistent with maturity structures of expected returns that are flat, upward sloping or downward sloping beyond a year. (p. 530)
>
> Though the evidence lacks statistical precision, it is interesting that there is no five-year subperiod of the 1953-82 sample period

> during which average bond returns increase systematically with maturity. The shortest-maturity bond returns increase systematically with maturity. The shortest-maturity portfolio (< 6 months) produces the largest average return in two of the five-year subperiods. Average returns never peak in maturity intervals beyond four years. At least on an ex post basis, the thirty-year period 1953-82 was not propitious for long-term bonds. (p. 538)

There is one weakness to Fama's approach. He aggregated bond returns by maturity groups. For the purpose here, it is desired to compare specific maturities. The aggregation may be the source of the higher variation noted by Fama and not the bonds themselves.

Empirical Results

Data

The data used came from the 1985 CRSP Monthly Government Bond Tape. This tape contains price data for all Treasury securities at the end of each month since 1939. This constrains the holding period to be one month or some multiple of months. Twelve month bills were issued from August 1963 to August 1973 at the end of each month. Fifty-two week bills have been issued every fourth week starting August 28, 1973. By adjusting for this four week procedure, price data are available for every maturity up to 12 months since August 1964. However, monthly issues for two-year Treasury notes began in the mid-1970s and data are available beginning January 1977. Month 12 is deleted entirely due to the high number of missing observations. The data set selected began January 1977 and ended May 1985, because this is the only period in which both bill and note returns are available.

Percentage price changes are calculated using continuous compounding. Because some securities do not mature precisely at month-end and months vary in length, an adjustment is made. The return is converted to a daily rate and then multiply by 30.4. This provides a consistent estimate of a monthly rate. (See Fama, 1984a and 1984b.)

Mean-Variance Rule

Table 3.1 gives the preliminary statistics. The M-V rule in this context is as follows: A return distribution of bills, say B(n), dominates the return distribution of notes, say N(n), where n = 1, 2, . . . , 11, by the M-V rule if, and only if, the expected return of B(n) is greater than or equal to the expected return of N(n) and the variance of B(n) is less than or equal to the variance of N(n) with at least one strong inequality. Obviously, the same approach is used in examining whether notes dominate bills.

Applying the M-V rules to the figures in Table 3.1 several conclusions can be drawn. First, making a comparison by maturity, notes do not dominate bills. Bills dominate notes for maturities 3, and 5 - 8. Therfore, bills appear to be preferable to notes when considering a one month holding period and maturities 3, 5, 6, 7, and 8 given

TABLE 3.1

Preliminary Statistics

1/77 through 5/85

	BILLS			NOTES		
Mat.	Mean*	Var.*	Skewness	Mean*	Var.*	Skewness
1	.7514	.2301	.607	.8125	.3101	.816
2	.8226	.2761	.825	.8375	.3240	1.149
3	.8451	.3221	1.293	.8093	.3653	.702
4	.8348	.3745	1.652	.8461	.3943	1.438
5	.8692	.4454	1.807	.8347	.4669	1.646
6	.8605	.5085	1.811	.8029	.5316	1.149
7	.8552	.5660	1.545	.8374	.5817	1.402
8	.8603	.6284	1.338	.8599	.6425	1.576
9	.8704	.7257	1.370	.8608	.6900	1.432
10	.8719	.8127	1.356	.8382	.7523	1.208
11	.8493	.8529	1.279	.8372	.7984	1.235

*Multiplied by 100

the assumptions of M-V criteria are not violated. That is, if investors are risk averse and returns are assumed normal, all investors will prefer to invest in bills rather than notes for purchase maturities of 3, 5, 6, 7, or 8 months.

Looking only at bills the efficient set contains maturities 1 - 3, 5, 9, and 10 so the inefficient set contains maturities 4, 6, 7, 8, and 11. For notes these sets are very similar; the efficient set contains maturities 1 - 2, 4, 8, and 9 leaving maturities 3, 5, 6, 7, 10, and 11 in the inefficient set. Thus taken separately there does not appear to be strong evidence in support of a economically meaningful term premium. Once again, the existence of positive skewness may invalidate the M-V results. Stochastic dominance criteria are applied in an effort to incorporate this skewness into the decision-making.

Applying SD and SDR Rules

The benefits of SD and SDR rules are that they allow inferences to be made with only partial information about investor preferences and require no assumption regarding the nature of the return distributions to be compared. See Chapter II for a description of these rules as well as a discussion about them.

Stochastic dominance rules are applied in an effort to establish a preference between one month holding period returns for bills and notes. That is, for each maturity (1 through 11) SD and SDR criteria are applied to the two distributions--bill and note. The results are given in Table 3.2 for both SD and SDR criteria. FSD has no discriminating power. A preference is established for FSDR for only maturity 3. SSD and TSD provide the same results. However, in the eighth maturity bills do not dominate notes as the M-V criteria indicated. Looking at SSDR, bills dominate notes for longer maturities. Using TSDR, discrimination is made in every period where in only maturities 1, 2, and 4 do notes dominate bills.

Finally all maturities for both notes and bills taken together are considered. It is clear in Table 3.3 that the majority of securities in the efficient set are bills for

TABLE 3.2

Efficient Sets by Maturity

1/77 through 5/85

Maturity	FSD	SSD	TSD	FSDR	SSDR	TSDR
1	B,N	B,N	B,N	B,N	B,N	N
2	B,N	B,N	B,N	B,N	B,N	N
3	B,N	B	B	B	B	B
4	B,N	B,N	B,N	B,N	B,N	N
5	B,N	B	B	B,N	B	B
6	B,N	B	B	B,N	B	B
7	B,N	B	B	B,N	B	B
8	B,N	B,N	B,N	B,N	B	B
9	B,N	B,N	B,N	B,N	B	B
10	B,N	B,N	B,N	B,N	B	B
11	B,N	B,N	B,N	B,N	B	B

SSD and TSD. Using SSDR and TSDR only bills remain in the efficient set.

TABLE 3.3

Efficient Set of bills and notes

1/77 through 5/85

Order	Maturity at Purchase bills	 notes
FSD	1-11	1-23
SSD	1-3,5	4
TSD	1-3,5	4
FSDR	2-10	1-9,13-23
SSDR	3,5	----
TSDR	3,5	----

Again, the sample size is large enough (101 observations) that by the simulation done by Kroll and Levy (1980) sampling error probabilities are small. However, exact probabilities are not possible because they assume specific distributions which do not resemble the distributions here.

Summary

Based on previous research a clear preference for bills or notes was not anticipated. The impact of coupons and differential tax treatment between bills and notes clouds the relationship of their before tax return distributions.

Examining monthly holding period returns of bills and notes for the period January 1977 through July 1985 indicated a preference for bills. Both mean-variance and stochastic dominance criteria made this indication. Therefore, notes cannot be considered a pure substitute for bills. Caution should be used when making inferences for longer holding periods.

CHAPTER IV
AN EMPIRICAL ANALYSIS OF GOVERNMENT DEALER SERVICES

In this chapter reported bid-asked spreads in the U.S. Treasury bill market are examined. Maturity is shown to be a measure of the instantaneous price risk borne by dealers in U.S. Treasury bills. Cross-sectional regressions are employed to determine what factors explain dealer bid-asked spreads. For the periods examined, maturity explained a large proportion of the variation in the bid-asked spread at a point in time.

In a perfectly competitive market, security dealer bid-asked spreads should be forced down to the inventory costs of dealers. If all dealers have the same cost functions, there will be no monopoly profits available.

In a world of complete certainty, the dealer bid-asked spreads should reflect three costs: (1) fixed costs, (2) non-financing variable costs per transaction, and (3) the cost of financing the dealer's inventory versus the returns earned from holding the inventory. In a world with risk and uncertainty, the risk of inventory price depreciation will be a fourth cost reflected in the bid-asked spreads. Finally, if some traders have access to superior information, then the bid-asked spread should incorporate the expected loss from trading with these people.[1] Prior studies of security dealer bid-asked spreads have focused on these five costs, as well as the extent of competition among dealers. Many studies have examined the question of the efficiency of the New York Stock Exchange specialist system or other stock trading systems.

This chapter examines the impact of risk (the fourth cost mentioned above) upon the bid-asked spreads in the U.S. Treasury bill market. It is shown theoretically that the dealer's price risk for holding a particular Treasury bill in inventory must be largely a function of the maturity. Empirically, differences in bid-asked spreads among Treasury bill's are shown to be explained by this risk measure. This implies that the Treasury bill market is a highly liquid market, where dealer spreads represent what Demsetz (1968) called the price of "immediacy."

Treasury bills have several desirable characteristics for studying bid-asked spreads. First, Treasury bills do not have default risk. In contrast, dealers in common stock are faced with the risk that the firm may default on some of its obligations with a resulting unexpected, but precipitous drop in the common stock price. Secondly, due to the immediate availability of information in this market, traders would not have access to superior information. In addition, there is no corporate insider problem. Thirdly,

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[1] See Glosten and Milgrom (1985).

Treasury bills do not pay coupons, making it much easier to measure their risk than the risk of coupon-bearing bonds, which have been the focus of previous studies of fixed income bid-asked spreads.[2] Fourthly, there are a large number of dealers in the Treasury bill market, strongly suggesting that competition will drive monopoly profits towards zero. This implies that at a particular point in time bid-asked spreads for different bills should be explained by risk differences. Fifthly, the par value outstanding of each Treasury bill issue is quite large and trades are range frequent, implying that bid-asked quotations will be relatively accurate. Sixthly, an extensive and reliable data base is available.

Previous Research

Stocks

Demsetz (1968) identified the bid-asked spread for stocks to be the cost to investors for immediacy. That is, investors would be willing to pay a dealer in order to consummate a transaction immediately rather than to bear the risk of a price change by waiting for a seller or buyer to arrive. Demsetz's primary focus was the influence of the scale of trading (as measured by the number of transactions per day) and of the number of markets on which a security is listed upon the bid-asked spread for New York Stock Exchange stocks. Demsetz found a significant negative relationship between the number of transactions per day and the (absolute and relative) bid-asked spread; he found a negative but non-significant relationship between the number of markets and the spread.

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[2] See Grant and Whaley (1978) and Tanner and Kochin (1971).

Tinic and West (1972) were the first to examine the impact of risk on the pricing of dealer services. They found that risk as measured by the relative of stock prices over a year[3] was not significantly related to the spread. Obviously this is not a good measure of risk so no conclusions are made.

Benston and Hagerman (1974) examined whether dealer markets are natural monopolies. In a study of 314 Over The Counter stocks, they presented some evidence in support of the existence of economies of scale. They showed that "trading scale (measured by the number of shareholders) is negatively related to spreads (a doubling in the number of shareholders is associated with a 16.5% decrease in spread)" (p. 363). They observe that this does not indicate that dealers are natural monopolist. They reported that "competition (measured by the number of dealers) is associated with lower per share spreads (a doubling of the number of dealers is associated with a 26.8% decrease in spreads)" (p. 363). This implies that dealers are in a decreasing cost industry with economies external to the individual dealer. Benston and Hagerman also found that the spread is significantly related to unsystematic risk, but not to systematic risk of the CAPM.

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[3] They measured range by (high price - low price)/mean price.

Stoll (1978a, b) theoretically and empirically addressed the question of the appropriate structure of the securities market by considering bid-asked spreads for NASDAQ stocks. He also attempted to identify what determines the appropriate number of dealers willing to make a market in NASDAQ stocks.

More recently, Stoll (1985) performed an economic analysis of the stock exchange specialist system. He identified three major cost categories: order processing costs, inventory holding costs, and adverse information costs. Order processing costs include fixed costs such as space, computers and equipment, most labor costs, and the specialist time. Also fixed costs for any transaction which may vary with the number of transactions such as per trade computer terminal charges, clearing fees, and variable labor charges. The last order processing costs are those which vary with transaction size such as greater clearing charges and special attention required of the specialist. Inventory holding costs refer to the cost associated with a dealer unbalancing his own portfolio (or inventory) thus giving the dealer additional risk. Adverse information costs refer to the losses to the specialist from trading with people with superior information. Traders with superior information can expect to make profits at the specialist's expense. Thus, specialist will charge larger fees, implying larger bid-asked spreads.

Bonds

Tanner and Kochin (1971) were the first to examine the spread determinants for government bonds. They examined empirically the determinants of spreads for Canadian government coupon-bearing bonds with maturities of two months to 28 years. Tanner and Kochin found that the spread had a positive relationship with maturity, a negative relationship with coupon, and a negative relationship with the quantity of bonds outstanding. They also found that spread was not related to yield to maturity.

Grant and Whaley (1978) re-specified Tanner and Kochin's (1971) work in an attempt to theoretically justify the included variables. They show that a bond's risk, as measured by its duration[4] (D), is an important determinant of the bid-asked spread (S). Using the par value of bonds outstanding (V) as a proxy for transaction volume, the following model was adopted:

$$S = a + b(1)V + b(2)D$$

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[4] Macaulay's duration is equal to the derivative of bond price divided by price times (1 + yield). This represents the instantaneous percentage change in bond price as interest rates change, assuming a flat term structure of interest rates.

They found b(1) to be significantly negative and b(2) to be significantly positive.

The Dealer's Inventory Problem

In a world of complete certainty, the dealer has an inventory problem. He must minimize his total cost of operating as a dealer. The dealer has fixed costs, which would include the following: rent on offices and equipment, communications expenses, such as telephone and subscription to an electronic quotation system, and salaries. The dealer also has non-financing variable costs, which depend upon the number of transactions; these would include costs of transferring the ownership of securities, incremental telephone costs, and incremental salaries. The third cost of a dealer is the cost of financing his inventory. Part of the inventory will be financed by equity. Since most dealers are highly levered, a large part of the financing cost will be debt cost in the form of short-term loans and repurchase agreements. It is expected that the financing costs are very heavily influenced by the level of money market rates, such as the repurchase rate and the short-term bank loan rate. As interest rates rise, dealer spreads should rise to reflect the higher cost of financing the dealer's inventory. (See Stigum (1983).)

In a world with risk or uncertainty, the dealer should quote bigger bid-asked spreads for securities that have greater risk of price depreciation.

Theoretical Considerations

The discussion to follow will examine the risk of Treasury bills in terms of yield to maturity.[5] The following notation will be used:

P = the current price of a Treasury bill

$R(j)$ = the yield to maturity on a Treasury bill with a maturity of j periods. j will be less than one for Treasury bills.

Yield to maturity and price are related as follows:

$$P = 1 / (1 + R(j))**j$$

where **j indicates that (1 + R(j)) is raised to the jth power.

To see the risk of a particular Treasury bill, take the derivative of price with respect to the shortest maturity interest rate, which is denoted by R(1).

$$dP / dR(1) = (-j / (1 + R(j))**(j+1)) * (dR(j) / dR(1))$$

Then divide by price to arrive at the percentage instantaneous price change.

$$dP / dR(1) / P = - (j / (1 + R(j))) * (dR(j) / dR(1))$$

---

[5] Treasury bills are usually quoted in terms of discount rates or bond equivalent yields. This practice appears to be a historical accident. Since the market for Treasury bills developed before electronic calculators, discount rates and bond equivalent yields were much easier to calculate than yield to maturity, which requires finding the jth root of the reciprocal of price. The practice has remained even though yield to maturity calculations are now quite convenient.

Thus, the instantaneous price sensitivity to interest rates depends on the bill's maturity, its yield to maturity, and the sensitivity of the yield on a j period bill to changes in the shortest maturity yield, R(1).

The term (1 + R(j)) will be a number close to one for every j. This term will not vary much for different j. Thus, it is expected to have a relatively small impact compared to the maturity, j. This is examined in detail below.

The last term, dR(j)/dR(1), represents the sensitivity of a particular bill's yield to maturity to changes in the yield to maturity on the shortest term bill. This sensitivity can be estimated by the following regression.

$$R(j) = a(j) + b(j)R(1) + e(j)$$

where b(j) is an estimate of dR(j)/dR(1) and e(j) is the residual error. Table 4.1 shows estimates of this regression for two 60 month periods (1) August 1964 through July 1969 and (2) July 1980 through June 1985. These two particular periods were chosen because in the 1960s interest rate changes were small while in the 1980s interest rates were volatile. Sixty months was chosen because it allows enough observations for a good estimate. The b(j) slope estimates are close to one for both periods, but especially for the less volatile interest rates in the 1960s. This suggests that the last term in the risk expression will have a relatively small impact, even though for the more volatile period b(j) is significantly different from one for some maturities. Consequently the instantaneous risk of a Treasury bill should be largely a function of its maturity. This is the hypothesis tested in the next section.

Price risk also depends upon the amount of time that inventory is held by the dealer. The average time between trades should be a function of the amount outstanding of a particular Treasury bill. This aspect of risk is also examined in the next section.

TABLE 4.1

Estimation of dR(j)/dR(1)

$$R(j) = a + b(j)R(1)$$

Maturity (Months)		8/64 - 7/69			7/80 - 6/85	
j	a	b(j)	R-Square	a	b(j)	R-Square
2	.49	0.9286 (.037)*	0.92	.92	0.9706 (.026)*	0.96
3	.36	0.9918 (.038)	0.92	1.34	0.9571 (.032)	0.94
4	.34	1.0086 (.041)	0.91	1.63	0.9398 (.035)	0.92
5	.97	0.9733 (.049)	0.87	2.14	0.9079** (.038)	0.91
6	.55	0.9991 (.054)	0.86	2.33	0.8971** (.041)	0.89
7	.63	0.9817 (.057)	0.84	2.70	0.8658** (.043)	0.88
8	.64	0.9935 (.062)	0.82	2.82	0.8606** (.043)	0.87
9	.49	1.0390 (.066)	0.81	3.08	0.8424** (.045)	0.86
10	.74	0.9739 (.061)	0.82	3.24	0.8321** (.047)	0.85
11	.78	0.9690 (.063)	0.81	3.44	0.8139** (.046)	0.85
12	.61	1.0242 (.068)	0.80	2.95	0.8469** (.074)	0.69

*Parenthetical amounts are standard errors of the estimate.
**Significantly different from one at the 5% level.

Empirical Results

Data

The data are taken from the Cross-sectional File on the 1985 CRSP Government Bond Tape. The study is limited exclusively to Treasury bills. For each observation point all Treasury bills recorded on the CRSP tape are employed.

Because bills are discount securities, their prices are inversely related to maturity. Therefore, the relative spread is used as the dependent variable. The relative spread is defined as follows:

$$S = (P(a) - P(b)) / P(ave)$$

where P(a), P(b) and P(ave) are the asked price, bid price and the average of the bid and asked price, respectively.

An Example

Table 4.2 presents univariate statistics for the 32 Treasury bills observed on June 28, 1985. The three variables considered are the maturity, the par value issued, and the market yield to maturity. Spreads rise with respect to maturity. The par value outstanding is larger for shorter maturities because the government issues 13 and 26 week bills every week and 52 week bills every four weeks. Thus, the shorter maturity issues add to the supply of the longer maturity bills already outstanding. Spreads tend to increase with a higher yield to maturity when yield curves are rising, but not when yield curves are declining. This point is considered later.

TABLE 4.2

Univariate Statistics for June 28, 1985

	Mean	Standard Deviation	Range	Correlation Vol.	Mat.	Yield
Spread (%)	0.019	0.012	.004-.048	-.58	.99	.89
Volume (mil.)	11,914	4,783	6,500-22,250		-.58	-.51
Maturity (days)	128	90	7-349			.91
Yield (%)	7.3	.285	6.6-7.8			

Regression Results

Table 4.3 presents the results of the regressions

$$S = a + b(V)V + e$$

$$S = a + b(M)M + e$$

and

$$S = a + b(M1)M1 + e$$

where V is the par value outstanding, M is the bill's maturity, M1 is the bill's maturity divided by (1 + R(j)), and e is the residual error. Observations are made annually starting the end of August, 1964. Notice that for all three regressions the slope has the anticipated sign except for insignificant coefficients for volume in August 1980 and 1984 and M and M1 in August 1980. The spread is negatively related to par value outstanding, although for some periods this is not a significant relationship (for example, August 1978). The R-square for maturity is more than double the R-square for par value outstanding for eight observation points. Thus, taken individually, maturity (or risk) appears to offer the best explanation for the variations in spreads at a point in time. Incorporating the divisor of the above risk measure (1 + R(j)) did not significantly change the results.

Table 4.4 presents summary statistics for the regression

$$S = a + b(V)V + b(M)M + e$$

TABLE 4.3

Single Variable Regressions

Date	Par Value Outstanding (Slope)	R**2	Maturity (Slope)	R**2	Maturity over Yield	R**2	Obs.
August	-1.08E-07	.52	7.15E-07	.54	7.43E-07	.54	37
1964	(.0001)*		(.0001)*		(.0001)*		
August	-8.87E-08	.34	8.93E-07	.64	9.32E-07	.64	37
1965	(.0001)		(.0001)		(.0001)		
August	-4.26E-07	.32	3.65E-06	.47	3.88E-06	.47	38
1966	(.0002)		(.0001)		(.0001)		
August	-2.56E-07	.45	1.35E-06	.20	1.43E-06	.21	36
1967	(.0001)		(.0056)		(.0054)		
August	-2.97E-07	.41	2.52E-06	.36	2.67E-06	.36	37
1968	(.0001)		(.0001)		(.0001)		
August	-3.51E-07	.34	3.74E-07	.48	4.05E-06	.48	38
1969	(.0001)		(.0001)		(.0001)		
August	-2.56E-07	.58	2.41E-06	.60	2.58E-06	.61	37
1970	(.0001)		(.0001)		(.0001)		
August	-1.36E-07	.42	2.00E-06	.52	2.11E-06	.52	37
1971	(.0001)		(.0001)		(.0001)		
August	-1.76E-07	.62	2.12E-06	.56	2.24E-06	.56	37
1972	(.0001)		(.0001)		(.0001)		
August	-1.72E-07	.28	3.84E-06	.64	4.19E-06	.64	38
1973	(.0007)		(.0001)		(.0001)		
August	-2.17E-08	.25	4.07E-06	.47	4.50E-06	.47	40
1974	(.0009)		(.0001)		(.0001)		
August	-1.16E-08	.47	2.29E-06	.65	2.47E-06	.65	40
1975	(.0001)		(.0001)		(.0001)		
August	-9.19E-08	.33	2.15E-06	.87	2.27E-06	.87	39
1976	(.0001)		(.0001)		(.0001)		
August	-4.93E-08	.41	9.73E-07	.88	1.04E-06	.88	39
1977	(.0001)		(.0001)		(.0001)		
August	-2.15E-08	.06	5.95E-07	.27	6.45E-07	.27	39
1978	(.1182)		(.0007)		(.0007)		
August	-3.94E-08	.25	6.55E-07	.28	7.26E-07	.29	39
1979	(.0011)		(.0005)		(.0005)		
August	1.03E-08	.02	-8.54E-08	.00	-9.48E-08	.00	35
1980	(.3998)		(.7583)		(.7596)		
Augsut	-8.10E-08	.35	3.52E-06	.73	4.15E-06	.73	32
1981	(.0004)		(.0001)		(.0001)		
August	-1.94E-08	.16	1.53E-06	1.00	1.71E-06	1.00	32
1982	(.0216)		(.0001)		(.0001)		
August	-2.02E-08	.27	1.53E-06	1.00	1.70E-06	1.00	34
1983	(.0015)		(.0001)		(.0001)		
August	6.37E-09	.01	1.39E-06	.79	1.56E-06	.78	34
1984	(.6319)		(.0001)		(.0001)		

*The probability of getting the observed t value given that the parameter is really equal to zero.

At the 1% level, par value outstanding is not significantly different from zero in most cases. With four exceptions, maturity is significantly positively related to the spread. Also the R-square does not improve dramatically for this multivariate regression over the single variable regression using maturity.

For twelve observation points, there exists significant positive first order autocorrelation. Other functional forms were examined with no improvement in the autocorrelation. For example, including an interaction term (M/V) and also taking the logs of the independent variables. However, the strong significance of the maturity variable indicates it's strong explanatory power.

Tanner and Kochin (1971) argue that " . . . the spread would be expected to vary directly with yield to maturity . . . because higher yields at any point in time on assets of given maturity probably reflect the intuitive feeling of investors about greater risk. . . . High spreads make higher yields on the purchase price necessary to induce the purchase of the bond by any individual having a nonzero prior estimate of his own probability of selling the bond before maturity" (p. 377). They found a positive but non-siginificant relationship.

Grant and Whaley (1978) assert that the derivative of duration with respect to yield to maturity is negative. Thus, they claim that as yield increases the price risk

TABLE 4.4

Multivariate Regression Results

Date	Par Value Outstanding (Slope)	Maturity (Slope)	R-Square	Durbin-Watson
August	-6.22E-08	4.48E-07	.64	1.1**
1964	(.0044)*	(.0019)*		
August	-1.70E-08	8.12E-07	.65	2.2
1965	(.4110)	(.0001)		
August	-1.60E-07	2.93E-06	.50	1.5
1966	(.1800)	(.0012)		
August	-2.81E-07	2.81E-07	.46	1.2**
1967	(.0004)	(.5544)		
August	-2.00E-07	1.38E-06	.47	2.0
1968	(.0118)	(.0487)		
August	-1.43E-07	2.91E-06	.51	2.0
1969	(.1341)	(.0014)		
August	-1.50E-07	1.51E-06	.72	1.7
1970	(.0007)	(.0003)		
August	-5.76E-08	1.46E-06	.55	1.3**
1971	(.1049)	(.0030)		
August	-1.17E-07	1.07E-06	.70	1.7
1972	(.0004)	(.0081)		
August	-1.18E-08	3.73E-06	.64	1.3**
1973	(.7843)	(.0001)		
August	-5.12E-08	3.63E-07	.48	2.0
1974	(.4401)	(.0003)		
August	-5.89E-08	1.75E-06	.74	.60**
1975	(.0014)	(.0001)		
August	3.21E-09	2.18E-06	.88	.55**
1976	(.7917)	(.0001)		
August	5.41E-10	9.78E-07	.88	.45**
1977	(.9299)	(.0001)		
August	1.13E-08	6.92E-07	.28	.47**
1978	(.4728)	(.0022)		
August	-2.22E-08	4.43E-07	.34	.89**
1979	(.1044)	(.0416)		
August	1.21E-08	7.09E-08	.02	1.3**
1980	(.4241)	(.8350)		
August	-8.68E-09	3.35E-06	.73	1.5
1981	(.6191)	(.0001)		
August	8.42E-10	1.54E-06	1.00	.57**
1982	(.0052)	(.0001)		
August	6.20E-10	1.54E-06	1.00	.43**
1983	(.0113)	(.0001)		
August	2.49E-10	1.38E-07	.79	2.0
1984	(.9682)	(.0001)		

*The probability of getting the observed t value given that the parameter is really equal to zero.

**First-order autocorrelation is significant at the 5% level.

decreases. They do not explicitly examine the relationship between spread and yield to maturity.

It is now shown that yield does not provide a meaningful explanation of the spread at a point in time. If the level of rates for different maturities is positively related to spreads, this relationship should hold for all yield curve shapes. In fact, it does not as shown by the following examples. Three points in time are examined; a declining yield curve (January 30, 1981), a relatively flat yield curve (June 30, 1981), and a rising yield curve (June 30, 1982). Table 4.5 presents the correlations for these three periods. In all three periods maturity is significantly correlated with the spread. However, for a flat yield curve, yield to maturity is not significantly correlated with spread. Also, note that for a declining yield curve, yield to maturity is negatively correlated with spread. For a rising yield curve, yield to maturity is positively correlated with spread. Contrary to the Tanner and Kochin (1971) hypothesis, it is found that the relationship between spread and yield to maturity depends on the shape of the yield curve.[6]

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[6] Also notice in Table 4.5 that the size of the average spread is much higher for a declining yield curve than for other shapes. Thus, a declining yield curve may indicate more uncertainty in the market leading to higher spreads.

TABLE 4.5

Correlation Matrices for Various Yield Curves

	January 30, 1981			June 30, 1981			June 30, 1982		
	(declining)			(Flat)			(Rising)		
	Vol.	Mat.	Yield	Vol.	Mat.	Yield	Vol.	Mat.	Yield
S	-.69	.94	-.76	-.66	.99	.16	-.60	.99	.77
V		-.68	.70		-.68	-.45		-.64	-.69
D			-.79			.16			.81
Observations		34			32			32	
Yield (%)									
Mean		15.5			15.7			13.8	
Std. Dev.		.496			.176			1.05	
Spread									
Mean		.00039			.00019			.00016	
Std. Dev.		.00026			.00013			.00011	

Summary

In this chapter the pricing of government dealer services in the U.S. Treasury bill market was examined for the period August 1964 through June 1985. It was found that maturity is a primary determinant of the variation in reported bid-asked spreads at a point in time. It was also demonstrated that, for a point in time, the market yield to maturity is not a significant determinant of the spread.

CHAPTER V
AN EMPIRICAL ANALYSIS OF TRANSACTION COSTS AND INFORMATION

This chapter examines the impact of bid-asked spreads in U.S. Treasury bills on assessments of future spot interest rates and future term premiums. Several different regressions are employed to determine the information in the observable term structure. Specifically, these regressions examine whether incorporating transaction costs alters conclusions regarding the information of forward interest rates. For most periods examined, incorporating the reported bid-asked spread does not change the results.

Most empirical examinations of the term structure of interest rates have used the average of the bid-asked spread as a price from which to calculate returns. (See, for example, Roll (1970, 1971), Malkiel (1966), Kessel (1965), Fama (1976a, b, 1984a, b), and Startz (1982).) This may stem from the common assumption of term structure theoretical models that there are no market frictions. However, market frictions have been identified as influencing the term structure.

Malkiel (1966, p. 103) identifies transaction costs as his first amendment to his "perfect certainty analysis" of the term structure. He claims that the only transaction costs paid by major investors in default-free bonds is the dealer bid-asked spread (Malkiel, 1966, p. 105). The bid-asked spread is the difference between the price that a dealer is willing to buy versus sell a particular security.

A Joint Economic Committee study in 1960 identified 17 dealers in U.S. Treasury securities. (See Meltzer (1960), p. 2.) By 1974 the number of dealers had grown to 24. (See Garbade and Silber (1976), p. 722.) The existence of transaction costs implies two separate participants in these securities. Because dealers take positions in securities and do not pay transaction cost, their holding period return will be higher than an investor who must buy at the asked price and sell at the bid price.

Two different assumptions can be made concerning the dealers true holding period return. Either it can be assumed that the dealers can buy at the bid price and sell at the asked price or they can buy and sell at the average of the bid and asked prices. These two assumptions are based upon who is actually buying and selling securities and result in different rates of return.

It has been suggested that many major participants in the Government securities market pay only a proportion of the bid-asked spread. (See Malkiel (1966), p. 115.) Garbade and Silber, based on interviews with dealers, concluded that reported bid-asked prices are " . . . real prices at which transactions take place for modest-size public orders, although not for large institutional trades" (1976, p. 730).

The hypothesis tested below is as follows. If either the dealers or the investors drive expectations in the bill market, then incorporating the bid-asked spread in return calculations will improve the prediction power from the term structure.

Previous Research

According to the unbiased expectations hypothesis, the implied forward interest rate should be an unbiased predictor of the subsequently observed spot interest rate. Several papers have tested this hypothesis by examining the difference between the implied forward rate today and the future observed spot rate. These prediction errors have been found to be positive on average and increasing with maturity. (See, for example, Fama (1976a) and Startz (1982).) These results have lead investigators to reject the unbiased expectations hypothesis. For example, Startz (1982) concludes, "A planner interested in future short rates would be well advised not to take today's implied forward rate as an estimator" (p. 237).

Another way of testing the unbiased expectations hypothesis, referred to as error-learning, has been presented by Meiselman (1962). The Meiselman approach correlates prediction errors between the nearest forward rate and the subsequently observed spot rate with revisions in distant forward rates. The prediction errors have been found to be highly correlated with revisions of distant forward rates, with these correlations decreasing as distance into the future increases. The Meiselman results have been regarded as strong support for the unbiased expectations hypothesis.

Thus, there have been several tests of the unbiased expectations hypothesis, with opposing conclusions. Brooks and Livingston (1986) demonstrate that although error-learning is found, the evidence is inconsistent with the unbiased expectations hypothesis. Therefore, they conclude that expectations affect the term structure, but not in the way suggested by the unbiased expectations hypothesis.

This present chapter extends the work of Fama (1984a). As will be described below, Fama uses the regression technique to make assessments about the information contained in the term structure.

The Model

Recently, Fama (1984b) assessed the information in the term structure based on the following two regressions.

$$PH(t+1,m) = a + b(F(t,m)-R(t,1)) + e(t+1,m) \qquad (5.1)$$

$$R(t+m-1,1)-R(t+1,1) = c+d(F(t,m)-R(t,1))+f(t+m-1,1) \qquad (5.2)$$

where $PH(t+1,m)=H(t+1,m)-R(t,1)$ is the holding period return premium, $H(t+1,m)$ is the holding period return observable at $t+1$ for a m maturity bill, $R(t,1)$ is the monthly spot rate, and $F(t,m)$ is the forward rate observable at t for the mth month. a and c are intercepts, b and d are slopes and e and f are the residuals. Under the unbiased expectations hypothesis, $b=0$ and $d=1$. That is because the unbiased expectations hypothesis implies

$$F(t,m) - R(t,1) = E(R(t+m-1,1) - R(t,1)) \qquad (5.3)$$

As Fama (1984b) argues, if b does not equal 0, then the forward rate contains information about premiums observed at $t+1$. If d does not equal 1, then the forward rate contains information about subsequent spot rates. By examining different participants in the market (dealer and investor) possibly better predictability will be found.

In addition to the above regressions, Fama (1984b) examined the "fine-tuned" regessions

$$H(t+1,m)-H(t+1,m-1) = a+b(F(t,m)-F(t,m-1))+e(t+1) \qquad (5.4)$$

$$R(t+1) - R(t+m-1) = c + d(F(t,m)-F(t,m-1) + f(t+m-1) \qquad (5.5)$$

Equation 5.5 assesses the ability of forward rates to predict " . . . successively more distant one-month future spot rates" (Fama, 1984b, p. 519). Equation 5.4 fine tunes the available information about the " . . . variations in the term structure of expected bill returns" (Fama, 1984b, p. 519).

These regressions are applied to an improved data set as well as extended to incorporate transaction costs. Two perspectives are taken, the dealer's and the investor's. For the dealer it is assumed that either the dealer receives the additional return of the bid-asked spread or the dealer does not receive this extra profit. For the investor it is assumed that he/she must pay the bid-asked spread thus receiving a lower return than average. Forward rates are calculated based on the average of the bid-asked spread.

Empirical Results

Data

The data available are on the CRSP Monthly Government Bond Tape. This tape contains price data for all Treasury securities at the end of each month since 1939. This constrains the holding period to be one month or some multiple of months. Twelve month bills were issued from August 1963 to August 1973 at the end of each month. Fifty-two week bills have been issued every fourth week starting August 28, 1973. By adjusting for this four week procedure, price data are available for every maturity up to 12 months since August 1964.

Percentage price changes are calculated using continuous compounding. Because some securities do not mature precisely at month-end and because months vary in length, an adjustment is made. The return is converted to a daily rate and then multiplied by 30.4. This provides a consistent estimate of a monthly rate. (See Fama, 1984a and 1984b.)

Regression Analysis

Table 5.1 summarizes estimated regressions of the premium on the forward-spot differential. These results are similar to Fama's (1984b, p. 517) except that the slope is higher for maturities two through six. Fama did not examine maturities greater than six months and the time periods are not exactly the same. The higher slopes are probably due to the examination of different time periods and not to the different data set. (These regressions were run on subperiods yielding almost identical results as Fama (1984b).)

The more important result is the lack of a significant change in the R-squared when bid-asked spreads were incorporated. Although the R-squared from the investor's perspective is slightly larger for early maturities this phenomena did not appear for all the subperiods. R-squares from the dealer's perspective tended to be smaller although this too did not hold for the subperiods.

Table 5.2 summarizes the estimated regressions of the change in the spot rate on the forward-spot differential. Again these results are similar to Fama (1984b, p. 517). The lack of a significant change in the R-squared when bid-asked spreads were incorporated implies that neither dealers

TABLE 5.1

Premiums on Forward-Spot Differential

Monthly Returns 9-64 through 5-85
$P(m,t+1) = a + b(F(m,t)-R(t+1)) + e$

	Average		Dealer		Investor	
Maturity	b	R-Square	b	R-Square	b	R-Square
2	.62	.24	.57	.20	.68	.32
	(.07)*		(.07)*		(.06)*	
3	.66	.11	.64	.09	.69	.13
	(.12)		(.13)		(.11)	
4	.92	.08	.88	.07	.93	.10
	(.19)		(.20)		(.18)	
5	.97	.10	.92	.09	.99	.13
	(.18)		(.19)		(.16)	
6	1.09	.09	1.00	.08	1.11	.12
	(.22)		(.21)		(.19)	
7	.77	.04	.81	.05	.78	.07
	(.24)		(.24)		(.18)	
8	.61	.02	.54	.02	.61	.02
	(.30)		(.23)		(.29)	
9	1.84	.13	1.87	.14	1.53	.11
	(.31)		(.30)		(.27)	
10	1.59	.09	1.82	.12	1.23	.07
	(.32)		(.31)		(.29)	
11	.55	.01	1.02	.03	.23	.00
	(.36)		(.36)		(.28)	
12	.85	.02	.91	.02	.78	.02
	(.43)		(.42)		(.41)	

*Parenthetical amounts are standard errors.

nor investors drive expectations in the market. Like Fama (1984a), it is found that the slope is not equal to zero. This is not supportive of the unbiased expectations hypothesis. That is, the forward rate contains information about term premiums observable at t+1.

Tables 5.3 and 5.4 exhibit the results of the "fine tuned" regressions. Here again the results are similar to Fama (1984b). Also the R-squares do not significantly

TABLE 5.2

Future Spot Change on Forward-Spot Differential

Monthly Returns 9-64 through 5-85
R(t+m)-R(t+1) = a + b(F(m,t)-R(t+1)) + e

	Average		Dealer		Investor	
Maturity	b	R-Square	b	R-Square	b	R-Square
2	.41 (.07)*	.12	.36 (.07)*	.10	.42 (.07)*	.13
3	.20 (.10)	.02	.16 (.10)	.01	.22 (.09)	.02
4	.31 (.13)	.02	.23 (.13)	.01	.34 (.11)	.03
5	.22 (.10)	.02	.17 (.11)	.01	.23 (.09)	.03
6	.09 (.11)	.00	.03 (.10)	.00	.12 (.09)	.01
7	.15 (.10)	.01	.04 (.10)	.00	.15 (.08)	.02
8	.26 (.12)	.02	.07 (.09)	.00	.36 (.11)	.04
9	.10 (.11)	.00	.03 (.11)	.00	.19 (.10)	.02
10	.20 (.10)	.02	.01 (.10)	.00	.31 (.09)	.05
11	.51 (.11)	.08	.17 (.12)	.01	.51 (.08)	.13
12	.33 (.12)	.04	.20 (.11)	.02	.39 (.11)	.06

*Parenthetical amounts are standard errors.

improve when the bid-asked spread is incorporated. In fact, the poor R-squares indicate that past maturity two there is no prediction power in future spot rates.

Table 5.3 is not supportive of the unbiased expectations hypothesis. There appears to be information today about changes in time varying premiums in the future. This should not be the case if the unbiased expectations hypothesis were true.

TABLE 5.3

Fine Tuned Premium Regression

Monthly Returns 9-64 through 5-85

$H(t+1,m) - H(t+1,m-1) = a + b(F(t,m)-F(t,m-1)) + e$

	Average		Dealer		Investor	
Maturity	b	R-Square	b	R-Square	b	R-Square
2	.62	.24	.57	.20	.67	.32
	(.07)*		(.07)*		(.06)*	
3	.53	.14	.50	.12	.57	.18
	(.08)		(.09)		(.08)	
4	-.37	.06	.33	.04	.42	.07
	(.10)		(.10)		(.10)	
5	.60	.26	.52	.19	.70	.33
	(.07)		(.07)		(.06)	
6	.40	.13	.29	.07	.53	.23
	(.06)		(.07)		(.06)	
7	.50	.24	.39	.13	.67	.46
	(.06)		(.06)		(.05)	
8	.37	.17	.10	.01	.64	.40
	(.05)		(.06)		(.05)	
9	.60	.26	.40	.13	.73	.37
	(.06)		(.06)		(.06)	
10	.61	.25	.68	.26	.59	.29
	(.07)		(.07)		(.06)	
11	.49	.36	.62	.39	.30	.13
	(.04)		(.05)		(.05)	
12	.23	.02	.16	.01	.28	.04
	(.12)		(.15)		(.10)	

*Parenthetical amounts are standard errors.

Table 5.4 is not supportive of the unbiased expectations hypothesis. The expected value of the slope was one if the unbiased expectations hypothesis is true. With the exception of month two, the slope is not significantly different from zero. For longer periods into the future, the forward-spot differential appears to be biased in its prediction of future changes in spot rates.

TABLE 5.4

Fine Tuned Spot Regressions

Monthly Returns 9-64 through 5-85

$$R(t+m) - R(t+m-1) = a + b(F(t,m)-F(t,m-1)) + e$$

Maturity	b	R-Square	b	R-Square	b	R-Square
2	.41	.12	.36	.10	.42	.13
	(.07)*		(.07)*		(.07)*	
3	-.10	.01	-.12	.01	-.08	.00
	(.09)		(.09)		(.09)	
4	-.11	.01	-.07	.02	-.14	.01
	(.09)		(.09)		(.10)	
5	.09	.01	.09	.01	.07	.00
	(.07)		(.07)		(.07)	
6	.05	.00	.03	.00	.06	.00
	(.06)		(.06)		(.06)	
7	-.10	.02	-.10	.01	-.08	.01
	(.05)		(.05)		(.04)	
8	.07	.01	.08	.01	.07	.01
	(.05)		(.04)		(.05)	
9	.10	.02	.07	.01	.11	.01
	(.05)		(.04)		(.06)	
10	.09	.02	.05	.01	.11	.02
	(.05)		(.05)		(.05)	
11	.12	.03	.09	.02	.12	.04
	(.04)		(.04)		(.04)	
12	.08	.01	.06	.01	.07	.01
	(.05)		(.05)		(.04)	

*Parenthetical amounts are standard errors.

Fama (1984a) showed that the autocorrelation in returns is not a problem in these regressions. The construction of equations 5.1, 5.2, 5.4, and 5.5 are first differences. That is, they are the differences in returns as opposed to using the actual returns. He reported significant first order autocorrelation when actual returns are used. He also reported that there is not significant first order autocorrelation using differences in returns. Therefore, the problem of autocorrelation was not addressed.

Summary

In this chapter the impact of bid-asked spreads in U.S. Treasury bills on assessments of future spot interest rates and future term premiums was examined. Regression analysis was used to make this assessment. For most periods examined, incorporating the reported bid-asked spread does not change the results.

Based on this analysis expectations of the dealers do not dominate the expectations of the investor nor do the expectations of the investor dominate the expectations of the dealers. Therefore, transaction costs do not significantly impact inferences made by examining the information in forward rates about future spot interest rates and time varying premiums.

CHAPTER VI
AN EMPIRICAL ANALYSIS OF TRANSACTION COSTS ON TERM PREMIUMS

The impact of transaction costs on term premiums cannot be ignored. Consequently, this chapter examines stochastic dominance results incorporating bid-asked spreads. The evidence suggests that term premiums are economically meaningful from a dealers perspective but not from an investors perspective.

Most empirical examinations of the term structure of interest rates have used the average of the bid-asked spread as a price from which to calculate returns. See, for example, Roll (1970, 1971), Malkiel (1966), Kessel (1965), Fama (1976a, b, 1984a, b), and Startz (1982). Fama (1976a, 1984b) and others have documented statistically significant term premiums. Having examined the economic meaning of these term premiums in Chapter II, the purpose here is to analyze the differences in the conclusions drawn when bid-asked spreads are considered. That difference can be analyzed by considering two views of the bid-asked spread. The dealer receives the benefit of the spread, whereas the investor bears the cost. Three perspectives will be analyzed: the dealer, the investor, and the average which is used for comparitive purposes.

To illustrate this analysis, suppose that both dealers and investors have a one month holding period. Both the dealer and the investor face a choice between purchasing a bill which matures in one month or purchasing a bill with n months left to maturity where n = 2, 3, . . . , 12 and sell it after one month where n-1 months to maturity are left. Because of transaction costs, the return distributions for the investor and the dealer are different. Therefore, it is possible for dealers to prefer month 5 to month 1, but for investors such a preference cannot be established.

In this chapter, whether there is an economic difference between the 12 distributions is tested rather than using statistical techniques. An economic difference exists if investors (or dealers) are better off by choosing one investment strategy over another. Efficient investment strategies are sought, that is, to recommend which maturities of bills constitute the efficient set of investment strategies. Clearly, the content of the efficient set is a function of the assumptions one is willing to make. Mean-Variance, Arditti's index, and stochastic dominance are applied in an effort to establish the efficient set.

Previous Research

In a study examining Treasury bill futures contracts ability to guage interest rate expectations, Poole (1978) notes that " . . . the relationship of transaction costs to term premiums has never been carefully investigated" (p. 92). Poole (1978) claims the following:

> The sharp drop in Roll's (1970) estimated marginal term premium--the average difference between the one-week implicit forward rate m weeks in the future and the one--week spot rate realized in m weeks--between the 13--and 14--week maturities appears to be suspiciously related to the sharp increase in the mean spread between the same two maturities. (p. 93)
>
> It is interesting to note that Roll (1970) found the hypothesis of market efficiency well-supported except for maturities of 4 to 8 weeks. For these maturities yields seem to be too low, on the average. We may conjecture, however, that the apparent anomaly would disappear with a fuller accounting of transactions costs. (p. 95)

The impact of transaction cost may dramatically change the results of all previous studies which use the bid-asked average rather than incorporate this transaction cost. A partial list of these studies include Roll (1970, 1971), Malkiel (1966), Kessel (1965), Fama (1976a, b, 1984a, b), and Startz (1982).

Mean-Variance and Mean-Variance-Skewness

Data

The data used came from the 1985 CRSP Monthly Government Bond Tape. This tape contains price data for all Treasury securities at the end of each month since 1939. This constrains the holding period to be one month or some multiple of months.

Twelve month bills were issued from August 1963 to August 1973 at the end of each month. Fifty-two week bills have been issued every fourth week starting August 28, 1973. By adjusting for this four week procedure, price data are available for every maturity up to 12 months since August 1964.

This data set is slightly different than that used in Chapter II because the FAMAFILE was constructed using the same bill from month 12 until it matured. The bills used here are those closest to month-end at month 6 as well as month 12 which yields more precise estimates of monthly holding period returns, reducing the amount of sampling error.

M-V Decision Rules

Average. As described in Chapter II, the M-V rules are applied to establish the efficient and inefficient sets using the average bid-asked spread. (See Table 6.1 for the means and variances.) Based on these criteria, months

1 - 3, 5, 6, 8, 9, 12 are in the efficient set and thus, months 4, 7, 10, 11 are in the inefficient set. These results are similar to those presented in Table 2.1. As described above, the only difference between these two tables is in the way monthly returns are estimated.

TABLE 6.1

Average Return Distribution

Monthly Returns 9/64 through 6/85

Maturity	Mean	Standard Deviation	Skewness	Sharpe's Index
1	.5576*	.2331*	1.156	0
2	.6029	.2706	1.343	.1674
3	.6248	.2989	1.655	.2248
4	.6232	.3280	1.996	.2000
5	.6457	.3758	2.219	.2344**
6	.6467	.4176	2.258**	.2134
7	.6452	.4539	2.022	.1930
8	.6529	.4937	1.857	.1930
9	.6591**	.5616	1.868	.1807
10	.6322	.6297	1.844	.1185
11	.6357	.6521	1.756	.1198
12	.6755	.7489**	1.987	.1574

*Percentage return on a monthly basis
**Peak

As in Table 2.2, by Sharpe's index, maturity five is the preferred investment. Also Arditti's measure implies an efficient set of maturities five and six.

Investor. By assuming the bills are purchased at the asked price and sold at the bid price, Table 6.2 presents the return distribution from the investors viewpoint. Notice that the average term premium is much smaller. For example, for month 9 the term premium for the average returns is .1015 (.6591 - .5576), whereas for the investor the premium is .0517 (.5951 - .5434). In this case, transaction costs account for approximately 50% of the term premium observed in average returns!

TABLE 6.2

Investors Return Distribution

Monthly Returns 9/64 through 6/85

Maturity	Mean	Standard Deviation	Skewness	Sharpe's Index
1	.5434*	.2343*	1.189	0
2	.5730	.2726	1.323	.1086
3	.5953	.3022	1.660	.1717**
4	.5879	.3333	1.970	.1335
5	.5975**	.3826	2.155	.1414
6	.5936	.4261	2.209**	.1178
7	.5830	.4645	1.964	.0853
8	.5877	.4995	1.830	.0887
9	.5951	.5642	1.838	.0916
10	.5570	.6263	1.736	.0217
11	.5515	.6526	1.722	.0124
12	.6003	.7433**	1.941	.0766

*Percentage return on a monthly basis
**Peak

Because of this marked decrease in mean returns, Sharpe's index peaks at month three rather than month five as before. Arditti's measure yields an efficient set of months 3, 5, and 6. By the M-V rules, months 1 - 3, 5, 12 are in the efficient set. Notice that by incorporating transaction costs, the efficient set is reduced by eliminating months 6, 8, and 9.

__Dealer__. By assuming the bills are purchased at the bid price and sold at the asked price, Table 6.3 presents the return distribution from the dealers viewpoint. Here the average term premium is much larger. The term premium for month 9, in this case, is .1512 (.7230 - .5718), which is almost three times the term premium from the investors perspective!

TABLE 6.3

Dealer Return Distribution

Monthly Return 9/64 through 6/85

Maturity	Mean	Standard Deviation	Skewness	Sharpe's Index
1	.5718*	.2325*	1.119	0
2	.6328	.2703	1.353	.2257
3	.6542	.2969	1.632	.2775
4	.6586	.3242	1.990	.2677
5	.6939	.3718	2.233	.3284**
6	.6997	.4127	2.243**	.3099
7	.7073	.4508	2.009	.3006
8	.7181	.4943	1.785	.2960
9	.7230	.5616	1.871	.2692
10	.7074	.6371	1.963	.2128
11	.7199	.6563	1.781	.2257
12	.7507**	.7570**	2.035	.2363

*Percentage return on a monthly basis
**Peak

Once again, Sharpe's index peaks at five months and Arditti's measure implies an efficient set of months five and six. The M-V efficient set is much larger consisting of months 1 - 9, and 12. Thus, the dealer market appears much more efficient in the sense that only months 10 and 11 are dominated. In the next section, stochastic dominance rules are employed because these distibutions are clearly non-normal.

Applying Stochastic Dominance

The benefits of stochastic dominance rules are that they allow only partial information about investor preferences and no assumptions regarding the nature of the distribution. This technique is developed in detail in Chapter II.

The results are in Table 6.4 where the riskless asset assumed is the average spot rate from each perspective. As indicated in the table, the FSD and FSDR criterion are very ineffective. For the dealer, however, month one is dominated by month two indicating that term premiums are economically meaningful for a dealer. Assuming $u''' > 0$ is not restrictive because SSD and TSD, and SSDR and TSDR contain the same securities in the efficient set. Incorporating a riskless asset in all three cases implies that term premiums are economically meaningful. As with the M-V criteria, the efficient set is smaller when transaction costs are subtracted from holding period returns, and larger when added. Because of the rising transaction costs with respect to maturity, longer maturities are dominated for the investor, whereas for the dealer, longer maturities move into the the efficient set.

TABLE 6.4

Stochastic Dominance Results

	Monthly Returns 9/64 through 6/85			
	FSD	SSD and TSD	FSDR	SSDR and TSDR
Investor	1-11	1-3,5	1-11	3,5
Average	1-11	1-3,5,6,8,9	1-11	3,5,6,8,9
Dealer	2-11	2-9	2-11	5-9

Summary

In this chapter, the influence of transaction costs on term premiums in U.S. Treasury bill holding period returns was examined. The existence of first-order stochastic dominance from a dealers perspective indicates that dealer term premiums are economically meaningful as well as statistically significant.

Term premiums are reduced dramatically by incorporating transaction costs, a fact which may vitiate most previous research in this area. In some cases, transaction costs account for 50% of the observed term premium. Assuming the existence of a riskless asset, however, still supports the existence of economically meaningful term premiums.

CHAPTER VII
CONCLUSIONS

The purpose of this study was to enhance the current understanding of the term structure of interest rates. Although our understanding of term structure behavior continues to be somewhat nebulous, five issues are now clear. First, determining whether term premiums of U.S. Treasury bills is economically meaningful depends on the assumptions made. Secondly, U.S. Treasury note's and U.S. Treasury bill's holding period returns are different, with bills dominating notes for many maturities. Thirdly, a primary determinant of reported bid-asked spreads at a point in time is the bill's maturity. Fourthly, incorporating the bid-asked spread does not improve the prediction power imbedded in the forward rates about future time varying premiums or future spot rates. Finally, transaction costs have a dramatic impact on term premiums.

Comparing the return of long-term bills to the return of short-term bills, a statistically significant term premium has previously been found by Fama (1984b). Whether this significant term premium is also economically meaningful was examined. If investors make decisions based on the relative characteristics of each maturity bill, then term premiums are not economically meaningful. If investors make decisions based on the portfolio distribution of each maturity bill and the riskless asset, then term premiums are economically meaningful.

The second problem was to establish a preference between return distributions of bills and notes. The impact of coupons and differential tax treatment between bills and notes clouds the relationship of their before tax return distributions. For the period examined, bills tend to dominate notes; therefore, notes cannot be considered a pure substitute for bills.

The third problem of examining the determinants of the bid-asked spread resulted in finding maturity as a significant determinant. A risk measure was developed which consisted primarily of the bill's maturity.

The fourth problem was resolved in that no significant change in R-squared was found in the regression analysis. It was concluded that there is no additional information in the bid-asked spread about time varying term premiums and forecasts of future spot rates.

Finally, transaction costs were shown to account for a significant proportion of the term premium. This result cast doubt as to the validity of prior research which ignores transaction costs.

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Robert Brooks was born on December 8, 1960, in Pensacola, Florida. He entered North Florida Junior College at Madison, Florida, earning an Associate of Arts in 1979. After earning a Bachelor of Science degree at Florida State University in Tallahassee, Florida, he entered the Ph.D. program in the University of Florida College of Business Administration in 1982 and was admitted to candidacy in 1985 after passing the qualifying exam in finance. Robert Brooks is currently employed as an Assistant Professor of Finance at Auburn Univerisity.

I certify that I have read this study and that in my opinion it conforms to acceptable standards of scholarly presentation and is fully adequate, in scope and quality, as a dissertation for the degree of Doctor of Philosophy.

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